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ABSTRACT

The third volume of a three volume study of the development and effectiveness of a computer-assisted instruction (CAI) course in undergraduate Physics contains the CAI curriculum. It is broken up into two parts, that is the 1500 CAI course and the problem sets presented via the 1440 computer. For a background and summary of the project see volume one (EM009605). For the learning materials and evaluative instruments used in the course, see volume two (EM009606). (JY)

CAI CENTER

FINAL REPORT
Project No. 7-0071
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RESEARCH AND IMPLEMENTATION OF COLLEGIATE INSTRUCTION OF PHYSICS VIA COMPUTER-ASSISTED INSTRUCTION

VOLUME III

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Technical Report No. 3

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TECH REPORT SERIES

The FSU CAI Tech Report Series is intended to communicate the research findings from studies and sponsored projects that have direct implication for the role of computers in education and training. The rationale for the tech report series is fourfold. First, the tech reports provide a convenient document format for reporting the results of all phases of large CAI projects. These projects typically span too many areas to be reduced into the more conventional research article format. Second, major computer systems designs will be presented in their entirety within the tech report series. Third, this series will provide colleagues at the FSU CAI Center an opportunity to develop major conceptual papers relating to all phases of computers and instruction. And fourth, all of the dissertations performed at the CAI Center will be published within this series.

In terms of content, one can anticipate a detailed discussion of the rationale of the research project, its design, a complete report of all empirical results as well as appendices that describe in detail the CAI learning materials utilized. It is hoped that by providing this voluminous information other investigators in the CAI field will have an opportunity to carefully consider the outcomes as well as have sufficient information for research replication if desired. Any comments to the authors can be forwarded via the Florida State University CAI Center.

Duncan N. Hansen

Director

Computer Assisted Instruction Center

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PREFACE

This report represents a long and diligent effort on the part of many individuals at Florida State University to investigate in a substantial manner the developmental and effectiveness factors in a collegiate level Computer-Assisted Instruction course in undergraduate physics. The challenge of creating a course for a computer-based presentation, especially at the beginning of the project in 1966, were considerable. The project was arduous both in terms of its size and challenge because of the full commitment to investigate all phases of the development, execution, revision and cost effectiveness of the CAI Physics Course from a research point of view. We trust that this report sufficiently describes the findings and proves useful to educators and researchers in terms of understanding the nature of CAI curriculum development as well as some possible implications as to its positive pay-off for collegiate instructions.

Past experience has indicated that a wide variety of scientists and educators will be interested in this report. Consequently, we have organized the final report into three parts in order to facilitate better dissemination. Volume I consists of the main body of the report. This covers the topics of 1) the statement of the problem, 2) the background literature, 3) the developmental curriculum processes, 4) a description of the multi-media techniques used within the course, 5) a set of CAI physics problem exercises, and, then, 6) the three subsequent field studies. Volume I is concluded with a presentation on cost analysis and a statement of what we consider the important conclusions. Volume II presents the appendices that describe in complete detail the nature of the learning materials and evaluative instruments utilized. This covers such topics as the course objectives, the data management system utilized for course monitoring and revision, booklet utilized by the students, presentation of audio lectures, homework problems, descriptions of films plus personality and attitude instruments. Volume III is a presentation of the CAI curriculum. This is broken up into two parts, that is, the 1500 CAI course and the problem sets presented via the 1440 computer. We trust this organization will prove useful to the different types of readers who would not want to be burdened with extra material unless they have an express purpose for it.

We wish to thank USOE and personnel in the Bureau of Research who have patiently advised and critiqued this project. We especially wish to thank Dr. Louis Bright for helping in the initiation of the project, plus Dr. Howard Hjelm, Dr. Andrew Molnar, Dr. William Adrian, and Dr. Howard Figler for their continuing interest and advice.

Here at Florida State University we wish to thank Dr. Steven Edwards, Dr. Gunter Schwarz, Dr. William Nelson, Dr. Neil Fletcher, and Dr. Robert Kromhout of the Department of Physics. Their conceptional advice, editorial assistance, and continuing interest were invaluable to the execution of this research project. We wish to thank Mrs. Ora Kromhout, Albert Griner, Joseph Betts, Marjorie Nadler, and Robert Hogan who authored the CAI materials. We wish to thank Mrs. Betty Wright, Mrs. Charlotte Crawford, and Mrs. Sharon Papay for their diligent efforts in coding and debugging the CAI course material. In turn, we wish to thank Mr. Beverly Davenport, Mr. Eugene Wester, and Mr. Wayne Lee for their efforts in developing the computer programs, especially in the area of data analysis, that allowed for the course revision. We wish also to thank our numerous, invaluable graduate students who contributed instrumentally in the development of the project. These were Kenneth Majer, Harold O'Neil, Leroy Rivers, Paul Gallagher, James Papay, and William Harvey. And lastly, the help of our secretaries in both the preparation and editing of this report was invaluable. We, therefore, wish to thank Louise Crowell, Dorothy Carr, Harvey Varner, Mary Calhoun and Ann Welton.

We trust that the findings from this report will prove useful and represents a sound investment on the part of the Bureau of Research of the U. S. Office of Education.

Duncan N. Hansen

Walter Dick

Henry T. Lippert

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Lesson 1

Listen to lecture 1.

Now that you've finished listening to your first lecture, you are entitled to take your first lecture quiz. This is standard procedure for the course; you'll be quizzed regularly on the various reading assignments and films, as well as the lecture content. These sessions are for your own personal benefit and will not be counted toward your grade. That doesn't mean you don't have to work at them, though. They will cover material you will be expected to know for your midterm and final exams. We'll start today with an easy set of questions. Let's see how well you can do.

1. The amount of matter an object has is measured in

   a. kilograms   c. seconds
   b. meters   d. hint

(ca) a. Exactly right. Incidentally, there are 1000 grams in a kilogram.

b. Sorry, wrong answer. Try again.

c. Come on now, let's get serious. You were asked for the unit of amount of matter, not time. Now type the proper letter.

d. What is a gram?

2. Meters are a unit of

   a. distance   c. force   e. hint
   b. time   d. mass

(ca) a. Good. Physics is pretty easy, isn't it?

b,c,d. No! No! No! You'd better listen to the last third of the lecture tape if you really don't know that meters measure distance.

e. Oh, come on now!

3. Recall that a physicist tries to understand the physical world by observing, measuring, and attempting to describe its phenomena. Answer yes or no to each of the following, depending on whether or not it is a suitable task for a physicist.

   a. yes   b. no   c. hint

(ca) a. Making detailed plans for a bridge? You're right. This would be a task for an engineer.

b. Wrong. A physicist wants to understand the physical world. An engineer makes use of what scientists learn in order to accomplish desired ends.

c. Does this primarily help understanding?

4. Thinking about the stars or the planets?

a. yes   b. no   c. hint

(ca) b. Well, it depends on what kind of thoughts. Thinking of how impressive the night sky is is not scientific although it is enjoyable. Wondering why the stars and planets are where they are is a task suitable for a physicist in his professional capacity, although he, too, is capable of thinking how impressive the night sky is.

a. It depends upon the kind of thoughts he is thinking. Type yes.

c. What kind of thoughts?

5. Measuring the length of his shoe with a ruler?

a. yes   b. no   c. hint

(ca) b. Correct. This probably wouldn't help him to achieve better understanding of the physical world.

a. Wrong. Would this activity help him to achieve better understanding of the physical world?

c. Does the act of measuring or the striving for understanding of physical phenomena differentiate the activities of a physicist from the activities of a non-physicist?

You have just completed your very first genuine computerized lecture quiz. It wasn't really so bad, was it? You may even have enjoyed it. We certainly hope so, since there will be many more to come.

The subject of the next lesson is "Measurement;" the assignment is sections 1.1 - 1.5 and 2.1 in your text, Elementary Physics, by F. W. Van Name, Jr. Please read it carefully and come prepared as you'll be quizzed on it. That's all I can think of to tell you for now; keep your cool and you may enjoy this course yet. Please sign off now.

(See Appendix for Anxiety Scale.)

Lesson 2

Read assignment quiz.

Hi, how are you today?

a. wonderful
b. O.K.
c. fair
d. lousy

(ca) a. Gee, you're the first person I've seen today that's in such a good mood. Congratulations.

b. Good. I'm feeling my transistors today myself.

c. Things could be worse, you know. I haven't seen the sun in three years.

d. Cheer up, graduation's only four years away.

Now, let's zip through a little quiz to see how well you understand your reading assignment.

1. The scientific method is by nature

a. inductive b. deductive

(ca) a. Very good, you picked that right out of the book.

b. No, it says right on page 5 of your text that it is INDUCTIVE. Let's try another question.

2. Solve for N. $2N + 4 = 9$

a. $N = 11$
b. $N = 6.5$
c. $N = 2.5$

(ca) c. Good work.

a, b. Wrong. To solve this subtract 4 from both sides,of the equation, then divide both sides of the equation by 2. The answer is $N = 2.5$. Let's continue.

Please make a choice.

Proctor call.

3. The system of measurement to be used in this course is the ________ system.

a. English
b. Witworth
c. Metric

(ca) c. That's right, we'll use it because it's easiest with which to work.

b, c. Wrong, we'll use the metric system because it is easiest with which to work.

Proctor call.

Please make a choice.

4. A^n means:

a. A to the nth power
b. n multiplied by itself A times
c. The nth root of A

(ca) a. That's exactly right.

b, c. Wrong.

Good.

The following response was displayed if all four of the reading quiz questions were answered correct.

Congratulations! You're off to an excellent start. Hope you'll keep it up. Since you did so well, we're going to reward you by letting you watch a movie (no popcorn provided). Please go and look at PSSC film 104, "Measuring Short Distances," then come back for a quiz on the film.

In this film, you will be introduced to several types of instruments which are used for measuring very short distances, and will be told about some of the uses and limitations of each.

Warning -- If the student answered two or three questions correctly:

You didn't do as well as you might have on this quiz, so we're going to let you make a decision. If you think you're not quite prepared to go on, review today's reading assignment and then when you feel you're ready, indicate "retake" for another try at the quiz. If you think you really know the material and just made some careless mistakes, then you're ready for PSSC film 104, "Measuring Short Distances." In this film, you will be introduced to several types of instruments which are used for measuring very short distances and will be told about the uses and limitations of each.

a. Continue. b. Retake quiz.

Off. If the student answered one or zero questions correctly:

Fie on you! We can't let you proceed at this rate. Whatever you were doing last night, it wasn't homework. Please sign off now, reread the assignment, and then sign on again to retake this easy quiz.

After viewing film:

Now here are some questions on the film you've just seen.

Film Quiz

1. Which instrument would most likely distinguish the smallest objects, such as molecules?

   a. optical microscope
   b. electron microscope
   c. field emission electron microscope
   d. field emission ion microscope

(ca) d. Your understanding seems to be quite clear.

a,b,c. No, pick the instrument which measures the smallest object.

d. Resolution is measured in units of length, and when we speak of the highest or greatest resolution, we refer to the smallest or shortest distance which the instrument can distinguish. Try again.

2. Instruments with various resolutions were described in the film. The __________ microscope has the lowest resolution.

   a. electron
   b. field emission ion
   c. optical (light)
   d. field emission electron

(ca) c. Right. It's resolution is limited by the wavelength of visible light.

It's the one that's probably the most familiar to you.

e. Please make a choice. Proctor call.

a, b,d. No, of these four, the optical microscope has the smallest resolution because it is limited by the wavelength of visible light.

3. Name which microscope is ordinarily used in biology labs.

   a. electron
   b. field emission ion
   c. optical
   d. field emission electron

(ca) c. Right.

a, b,d. Optical is the correct answer. It is well suited for this use, having sufficiently high resolution for most purposes and not requiring elaborate equipment or power supplies. Now, try again.

e. The name is a clue.

4. If equipment and money were no object, is it desirable to have the highest resolution instrument instead of the optical microscope for all laboratory work?

   a. yes
   b. no

a. It certainly would not. Such a high resolution instrument would examine only a very small area of the specimen at a time. In most cases, you would not be interested in such a fine structure, but would need a "field" that is thousands of times larger than atomic distances in order to study a reasonable area of the specimen at a time. Try again.

(ca) b. You are right.

You have now completed the film quiz and - surprise - we're not going to ask you to repeat anything regardless of how you did. Now please sign off and dial for the text of lecture 2, "Measurement." When you have finished with it, return to this terminal and sign on for your third (and last) quiz of the day.

Here are a few questions on the lecture to which you just listened.

Lecture Quiz

1. In the best scientific notation, $4.7 \times 10^{-2} - 7 \times 10^{-3} = ?$

   a. 0.4×10^{-5} c. 4×10^{-2}

   b. 0.4×10^{-2} d. hint

(ca) c. Very good.

a. Remember, before adding or subtracting, numbers must be written in terms of the same power-of-ten. Try writing both numbers in terms of 10^{-2}. Try again.

b. Almost, but not quite. This problem could be rewritten as follows:

$$4.7 \times 10^{-2} - .7 \times 10^{-2}.$$ Try again.

d. Please make a choice.

2. The kinetic energy of a moving object is expressed by the relationship

   $K.E. = (1/2)\ m(v^2)$ where m = mass, and v = velocity. Calculate K.E. for $m = 100$ Kg, $v = 30$m/sec.

   a. 1.5×10^4 Kgm^2/sec^2 c. 45×10^4 Kgm^2/sec^2

   b. 4.5×10^5 Kgm^2/sec^2 d. hint

a. No. Be more careful when you square the velocity.

(ca) b. You do good work.

d. In this equation, $m = 1.0 \times 10^3$ Kg, $v = 3.0 \times 10^1$ m/sec. Try again.

c. That's the right answer, but it is not expressed in good scientific notation. Revise it and try again.

3. In best scientific notation, $(400)^2 + 300{,}000$ is

a. 4.6×10^5
b. 7×10^5
c. 1.4×10^5
d. hint

(ca) a. Very good.

b, c. No. I think you have made a mistake in your arithmetic. Work it again then choose another response.

d. $(400)^2 = (4 \times 10)^2 = 16 \times 10^4 = 1.6 \times 10^5$

$300{,}000 = 3.0 \times 10^5$. Try again.

4. Using scientific (powers of ten) notation, calculate the following: $.00418 \times 39.7$. Choose the correct answer expressed in scientific notation form.

a. 1.61×10^{-1}
b. 1.66×10^{-1}
c. .166
d. hint

(ca) b. Very good. Your calculation was exactly correct.

d. Set the numbers in scientific notation, perform the arithmetic operations called for, set the results in scientific notation.

a. Your error indicates that you did not round off your arithmetic properly. Be more careful in the future. Choose the correct answer now.

c. This is the correct answer, but it is not expressed in scientific notation. Choose the correct answer.

5. Choose the correct answer in the proper scientific notation form for this problem: $648{,}000. \times 3250.00$

a. 2.10600×10^9
b. 2.106×10^6
c. 21.1×10^8
d. hint

(ca) a. Well done, 'a' is the proper solution.

b. Wrong. Try your calculations again--be more careful.

c. No. This answer is incorrect. The decimal point is placed such that the number is not expressed between unit and ten. This is incorrect notation.

d. Make a choice.

6. Using scientific notation, calculate the following and choose the correct notation-form answer:

$$\frac{.3650}{.01520}$$

a. 2.401×10^1 c. 2.430×10^1

b. 2.401×10^2 d. hint

(ca) a. Excellent. Your division utilizing scientific notation is apparently quite accurate.

b. Wrong. Better learn to count decimal places with more accuracy. Try again.

c. Your arithmetic could use improvement.

d. Convert carefully to scientific notation before performing division.

7. Calculate the following utilizing scientific notation:

$$\frac{10.0 \times 10.0}{1.0}$$

a. 100 c. 1.0×10^2

b. 1.00×10^3 d. hint

(ca) c. Good job. Apparently zeros don't fool you as easily as they fool me.

a. This is the correct number, but it is not in scientific notation form. Select the correct answer.

b. Zeros can be tricky. Try again.

d. This is as simple as it looks. Just don't forget to convert to scientific notation.

If you feel you have had a great deal of trouble with these problems in scientific (powers of ten) notation, you trouble probably lies in one of two areas: (1) understanding scientific notation or, (2) arithmetic. If the problem is arithmetic, friend, I'm sorry. You'll have to get that on your own. If your trouble is understanding and working with scientific notation, refer to pages 14-21 of your text Elementary Physics, Van Name, Jr.

Now, we'll try some order of magnitude problems.

8. There are about 73,000 people living in Leon County, of whom about 48,000 live in Tallahassee. The order of magnitude of the number of people living in Leon County outside Tallahassee is:

a. 10^5 b. 10^4 c. 10^3 d. hint

a. No, as the number of people living in Leon County outside of Tallahassee is 25,000 which is much less than 10^5 or 100,000.

b, d. In good scientific notation, write the number of people living outside Tallahassee in Leon County -- the nearest power-of-ten to that number is the order of magnitude. Now, answer correctly.

c. Good.

9. What is the order of magnitude of the repeating fraction 3/7?

a. 10^0 b. 10^1 c. 10^{-1} d. hint

a, b. Wrong, remember that the order of magnitude of a number is the nearest power-of-ten to the number involved. Now find the right answer.

d. Set the decimal fraction in scientific notation and consider the power-of-ten.

(ca) c. Correct.

10. If the national debt were 10 million dollars, what is the order of magnitude of the nationl debt in CENTS?

a. 10^7 b. 10^8 c. 10^9 d. hint

(ca) c. Good.

a. Wrong. That is the order of magnitude of the national debt in dollars. Now select the correct answer.

b. No. That is the order of magnitude of the national debt in dimes. Now answer correctly.

d. Convert to scientific notation, then to cents and consider the power-of-ten.

That was a pretty long lesson today. Next time you'll see a film starring King Kong. Read section 2.1 in your text for next time. Better write that down.

Now, please type 'sign off' so I get some sack time.

Lesson 3

Textbook Quiz

1. We had a system in which the standard units of measurement were the dustpan, the broom and the mop. If we multiplied one dustpan per broom^2 by two brooms, we would have:

   a. 1 mop
   b. 2 dustpans per broom
   c. 2 mops
   d. 2 brooms^2 per dustpan

(ca) b. Good! You understand the principle of cancelling units.

a,c,d. You don't yet understand how units are cancelled. Consult page 26 in your text, Van Name, Jr.

2. Which statement is true?

   a. A yard is slightly over one meter.
   b. A kilometer is greater than a mile.
   c. A meter is slightly over a yard.
   d. A micrometer is greater than a millimeter.

(ca) c. Fine.

a,b,d. You blew your cool on that one.

3. The conversion factor between centimeters and inches:

   a. 1 inch = 2.54 cm.
   b. 1 cm. = 2.54 inches
   c. 1 inch = 25 cm.
   d. 1 cm. = 25 inches

b,c,d. No, better review your material. This is rather important in that it gives you an idea of what a centimeter is.

(ca) a. Good.

4. In our physics course, the standard of length is the _______.

   answer: meter

(ca) Very good!

(wa) No, we use the METER as the standard of length in physics.

5. How many centimeters are in a meter? (Type in your answer as a number.)

   answer: 100

(ca) Very good; since there are ten millimeters per centimeter, it follows that there are 10 x 100 = 1000 millimeters in a meter.

(wa) Wrong. A centimeter is 1/100 of a meter so there are 100 centimeters in a meter.

Warn

If 3 or 4 are correct on reading quiz:

You didn't do as well as you might have, so it's up to you whether you want to re-read the assignment and then retake this quiz or simply proceed directly to lesson 3, "Scaling." If you want to go on, get out your supplementary material for this lesson and go listen to the lecture.

You chose to retake the quiz--review the assignment and then touch the retake choice when ready to proceed.

Go to lecture quiz.

Retake quiz.

Good

If 5 correct on the quiz:

Excellent. You did very well, so you're ready for the next plateau. Go listen to lecture 3 on "Scaling," and have your supplementary material for this lesson handy.

Lecture 3 - Display before Film Quiz.

All right; let's see how much you've learned about King Kong and related topics. Let's proceed.

Film Quiz

1. Rope A has three times the diameter of rope B. They are made of the same material. A is ________ as strong as B.

   a. three times   c. nine times
   b. one-tenth   d. hint

(ca) c. Very good. Let's do another one.

2. In the film, two putty bars were molded, one ten times larger than the other in each dimension. Which one of the bars was too weak to support its own weight?

   a. smaller   c. larger
   b. neither   d. both

(ca) c. Right.

a,b,d. The larger bar that collapsed. Compared to the smaller bar it was (ten to the second power), or 100 times stronger, but (ten to the third power), or 1000 times heavier, and was therefore not strong enough to support its own weight. Try again.

3. This happened because the _______ of the bar increases with the THIRD power of the scaling factor, while the strength, being a function of the cross-sectional area, increases only with the _______ power of the scaling factor. (Type the correct words.)

answer: weight second

Good. Let's continue.

<u>If timed out or wa</u>:

The WEIGHT of the bar increases with the third power, the strength with the SECOND power. The larger bar is 1000 times heavier, but only 100 times stronger. Try again.

Please type in weight second.

<u>Hint</u>:

Strength is proportional to cross-sectional area, but weight depends on <u>volume</u>, which depends on the scale factor cubed.

4. Remember the large and small safes, one ten times larger in each dimension than the other? The larger one is _______ times heavier than the smaller one. (answer: 1000)

(wa) Exactly. One is (ten x ten x ten) or 1000 times heavier. Enter the correct answer now.

(ca) 1000.

<u>Hint</u>:

This problem is much easier than the last few you've done. If you got through those, you can get through this one, too!

5. The nylon rope on which the safe is hunt therefore needs to be 1000 times stronger. How much larger diameter need the rope have?

a. 10 times
b. 100 times
c. square root of 1000 times
d. hint

a, b. No since the strength increases with the square of scaling factor, this would only be 100 times stronger, and we need a rope 1000 times stronger. Try again.

(ca) c. Very good.

d. Strength increases with the square of the scaling factor. Therefore if we do as you suggest, we would have (100 to the second power) or 10,000 times which is more strength than we need. Try again.

int. Remember what we've been telling you about the relationship of strength and scaling factor.

Lecture Quiz

Here is your quiz on what we've covered just now on the subject of scaling. Let's see how much you remember.

1. In the relationship expressed by Y=24, each value assigned to x determines a value of y. Thus, y is a function of x. This particular function is a:

   a. linear function c. quadratic function
   b. cubic function d. hint

(ca) a. Excellent

b, c. No, if this were a cubic function, y would vary as x^3.

d. A linear function means that y varies directly as x. A quadratic function means y varies as x^2. A cubic function means y varies as x^3.

2. The area contained in a circle is proportional to the ________ of the circle.

   a. radius c. square of the radius
   b. cube of the radius d. hint

(ca) c. Correct.

a. Incorrect. Remember that for a circle, A = (   ) x (r^2). Now answer the question correctly.

d. If you were ordering vinyl tile to cover a floor <u>area</u> in your home, would you measure the area to be covered in feet, square feet, or cubic feet? Try again.

b. I'm sorry. The volume of a sphere is proportional to the cube of the sphere's radius; here we are only looking for the area of a circle. Now answer correctly.

3. If the temperature (T) of a gas is increased but its volume is kept constant, the pressure (P) on the walls of its container will be given by the relationship P = cT. This means that if the temperature is tripled, the pressure of the walls will:

   a. increase b. decrease c. remain the same d. hint

(ca) a. Right you are.

b, c. No, the relationship implies that if the temperature is increased while the volume is kept constant, the pressure will also increase by a proportional amount. Try again.

hint. If you really can't tell just from looking at the equation, plug in some values for T.

4. In a certain experiment it is found that the weight of a piece of lead is a function of its volume. This means that:

    a. irrespective of volume, all pieces of lead weigh the same.

    b. two pieces of lead with the same volume will have the same weight.

    c. it is impossible to find the weight of a piece of lead knowing the volume.

    d. No-- that the weight is a function of the volume means that the value of the weight depends on the value of the volume.

(ca) b. Correct.

d. Come on now! The question is a hint.

c. No, since weight is a function of the volume for any volume the weight can be calculated if the constant of proportionality is known.

5. Suppose you scale up all the linear dimension of a steel wire by a factor of three. By what <u>factor</u> does each of the following change? (Type the numeral that answers the question correctly.)

Volume?

(ca) 27
Wrong.
Right.

hint. This is one of a number of such relationships given in the lecture that you'll just have to memorize

6. Mass?

(ca) 27
Wrong.
Right.

hint. This is one of a number of such relationships given in the lecture that you'll have to memorize.

7. Surface area?

(ca) 9
Wrong.
Right.

hint. This is one of a number of such relationships given in the lecture that you'll just have to memorize.

8. Breaking strength?

(ca) 9
Wrong.
Right.

hint. This is one of a number of such relationships given in the lecture that you'll just have to memorize.

9. Cross-sectional area?

(ca) 9
Wrong.
Right. The answer is 9.

hint. This is one of a number of such relationships given in the lecture that you'll just have to memorize.

10. Heat loss.

(ca) 9
Wrong.
Right.

hint. This is one of a number of such relationships given in the lecture that you'll just have to memorize.

11. Circumference of cross-section.

(ca) 3
Wrong.
Right.

hint. This is one of a number of such relationships given in the lecture that you'll just have to memorize.

12. King Kong would have to be a lot sturdier than shown in the movie to support his own weight. Since he is 50 times taller than normal, his weight is how much greater?

a. 50 times   c. 50^2 times normal

b. 50^3 times normal   d. hint

(ca) b. Exactly.

a, c. No, his weight is 50^3 time normal. Type in the correct answer.

d. Remember weight is proportional to volume.

13. How much stronger than normal are his legs?

a. 50 times c. 50^2 times

b. 50^3 times d. hint

(ca) c. Correct

a, b. No, the strength of his legs is proportional to the cross-sectional area, therefore, to the second power of length.

d. Strength is proportional to cross-sectional area, remember?

14. A certain animal is scaled down by a factor of 1/10. As a result, his weight is reduced by:

a. 1/100, strength by 1/100
b. 1/1000, strength by 1/10
c. 1/1000, strength by 1/100
d. hint.

(ca) c. Very good.

a, b. No, your answer is wrong. Remember that the strength of bones increases or decreases by the square of the scaling factor while the weight of the animal increases or decreases by the cube of the scaling factor. Try again.

d. Come on, think! You've done lots harder problems than this already.

15. Why would it be physically impossible for the Brobdingnagian giants in Gulliver's Travels to actually exist?

a. Not enough food would be available to satiate their appetites.

b. The weight-to-strength ratio of their bones would not enable them to support their own bodies.

c. Gulliver's Travels is a fairy tale.

d. Hint.

(ca) b. Good. You seem to have the general concept of scaling.

a, c. No, you'd better go back to the physics textbook by the Physical Science Study Committee and review scaling. Try again.

d. Remember, bone strength varies as the square of the scaling factor, while weight varies as the cube of the scaling factor.

16. A sphere, A, of plastic has a mass of 10 grams. Another sphere, B, of the same plastic has a mass of 10,000 grams. What is the ratio of the diameter of B to the diameter of A?

a. 10 b. 100 c. 1/100 d. hint

(ca) a. Correct

b, c. No, the ratio of the mass of B to the mass of A is 10,000 grams/10 grams = 1000. Since mass is proportional to volume, the ratio of the volumes is also 1000. Volume is a function of the third power of the scaling factor. Therefore, the scaling factor is the cube root x 1000 which is 10, (10 x 10 x 10 = 1000).

d. This problem contains nothing new; just use the contents of your cranium.

Lesson 4

Reading Quiz

1. The rate of change of velocity is called _________.

Good work.

(ca) Acceleration.

(wa) Wrong. Rate of change of velocity is ACCELERATION.

2. The acceleration due to gravity near the surface of the earth is _________ m/sec^2.

(ca) 9.8

(wa) No. Remember the book said that acceleration due to gravity is 9.8 m/sec^2.

3. A unit that requires both a magnitude and a direction is called a _________.

(ca) vector

(wa) scalar. No. A scalar has magnitude only. The answer is vector.

(un) No, such a quantity is called a vector.

4. A quantity or unit that requires only a magnitude is called a __________.

(ca) scalar. Now you know the difference between scalars and vectors.

(wa) Watch your spelling.

5. A car starts from rest and accelerates uniformly to a speed of 50 miles per hour in 15 seconds. Its average speed during that period is ________ miles per hour. Type a numeral only.

(ca) 25.

Right. For uniform acceleration, average speed is equal to 1/2 the sum of initial and final speeds.

(un) The initial speed is zero, final speed is 15 miles per hour. So the correct answer is 25.

Warn

You didn't do too well, so we're giving you a choice here: you can proceed with lecture 4 on vectors, you can sign off, or you can quickly review the reading assignment and then take this quiz over. If you want to go on right away, go listen to the tape for lecture 4 now. If, on the other hand, you'd like another crack at this quiz, refresh your memory on the reading assignment and then indicate "retake quiz" when you're ready to try again.

Continue   Retake quiz

Good

Fine. You're ready to go ahead. Now go and listen to lecture 4 on vectors; then come back here and we'll test how much you got out of that.

Off

Nope--we can't let you get by with that. Sign off, reread the assignment, and come back when you're better prepared.

Display before lecture quiz:

Now for a quiz on the content of the lecture you just listened to, on vectors. Let's see how much you remember.

1. An aircraft flies north at 100 mph. There is a cross wind blowing east at a speed of 50 mph. In what direction and at what speed will the plane end up flying? (Let 1/4 inch = 25 mph in your drawing.)

a. Northeast at 90 mph   c. North at 100 mph
b. Northeast at 112 mph   d. hint

(ca) b. We know from the laws of vector addition that (1) the speed of the aircraft must increase and, (2) the direction of the aircraft is changed in THE DIRECTION OF THE WIND.

a. No, the speed is wrong. We know from the laws of vector addition that the speed of the plane MUST increase. You're close to the correct direction. Reconstruct the vector diagram and try the problem again.

c. You are exactly right as far as the direction is concerned. However, the accuracy to which you measured the speed is not enough. Redraw the vector diagram and try the problem again.

d. Try drawing a scale diagram.

2. Now for a more complex problem. Suppose starting at Westcott Building, you take the following walk: 1 block north, 1 block east, 2 blocks north, 2 blocks west, 1 block south, 2 blocks east, 2 blocks south, and 1/2 block west. Your net displacement at the end of your trip is:

a. 1/2 block east c. 2 1/2 blocks
b. 1/2 block west d. hint

(ca) a. Good. And in case you're interested, you are in front of the Zeta house--halfway down the hill in front of Westcott.

b, c. No, in this case, the answer is the resultant vector.

d. Add up the portions of the walk as vectors. The resultant is the answer.

3. A vector 13 feet long is resolved into Cartesian components. If the x component is 12 feet long, the y component could be:

a. 1 foot long b. 5 feet long c. zero d. hint

a. No. Remember that the magnitude of a vector is the square root of the sum of the squares of the Cartesian components. Your answer would give a resultant vector of (sq. rt. (12^2) + (1^2) = (sq. rt. 1.45) feet which is less than 13 feet. Try again.

4. Which of the following is a vector?

a. finite rotations c. speed
b. displacement d. hint

a. No, in adding finite rotations the resultant depends on the order in which they are added. This is not true of a vector.

c. No. Speed is a scalar, velocity is a vector.

d. Finite rotations count the number of rotations, speed gives the distance traveled per unit time, but not direction and displacement gives a distance and a direction.

(ca) b. Right you are. Very good.

5. A vector whose magnitude is 5 could be the sum of a vector whose magnitude is:

a. 10 and one whose magnitude is 3
b. 3 and one whose magnitude is 5
c. 17 and one whose magnitude is 10
d. hint

(ca) b. Right, and in case you are interested, the vectors are at an angle of 72 degrees to one another.

a, c. No, if the two vectors are pointing opposite to one another the smallest vector they could form would have a magnitude of 7. Try again.

d. Try adding the vectors to get the smallest resultant.

6. A pilot on a reconnaissance flight from the Saigon airport flies north for 50 miles, west 100 miles, south 75 miles. He turned east and flew at 80 mph for one hour and 15 minutes. How far and in what direction did he have to go to get back to the airport?

a. 20 miles east c. 0 miles
b. 25 miles north d. hint

a, c. No. Go through the problem carefully again and draw his path to scale if necessary, then type in the right answer.

(ca) b. That's right.

d. Add the distance and direction as vectors.

7. A fisherman in Key West knows that to get to the best spot to catch sailfish, he must go 4 miles south of the harbor, and then go 3 miles west. How many miles can he avoid traveling by sailing directly from the harbor to his fishing spot?

a. 2 mi. b. 5 mi. c. 3 mi. d. hint

(ca) a. Good. The straight line distance to the fishing spot is 5 miles, which is 2 miles less than the 4 miles south and 3 miles west he travelled to get there.

b, c. No. The straight line distance from the fishing spot to the harbor is 5 miles. Now find how many miles he can save and answer the question correctly.

d. Draw the triangle and measure the distances involved. How many miles can he save?

8. A man takes the following trip: starting from home he travels 10 blocks south, 12 blocks east, 2 blocks south, 7 blocks west, 8 blocks north, 5 blocks west, 4 blocks north. His net displacement at the end of this trip is:

a. 48 blocks   b. 12 blocks south   c. zero   d. hint

(ca) c. You're right, he has returned home.

a. No, remember that displacement is a vector and that when adding vectors you must consider their direction.

b. No, your arithmetic seems to be incorrect. Try again.

d. Add the blocks and directions as vectors.

9. Here is a question you may find on the midterm: a vector 4 feet long could be added to a vector 3 feet long to produce a vector whose length is ______ feet.

a. 8 feet   b. 5 feet   c. .5 feet   d. hint

b. No. With only two vectors--one 4 feet and the other only 3 feet long--there is no possible way we can add them and get a resultant vector longer than the sum of the two original vectors (7 feet in this case). Rework the problem and select the correct answer.

d. Find both the longest and shortest possible resultants of the vectors.

(ca) c. Good.

a. No. There is no possible way we can add a vector having a 4 foot length to another vector 3 feet in length and achieve a resultant shorter than the difference in the length of the two vectors. Rework the problem and select the correct answer.

10. A car travels in a straight-line path but with increasing speed. With this information we know its acceleration is:

a. Constant in magnitude but not in direction.
b. In the same direction as the velocity.
c. Constant in direction, but not in magnitude.
d. hint

(ca) a. Correct. With this type of acceleration the velocity changes in magnitude but not direction.

b. Wrong. The acceleration does have constant direction. The same direction ias the velocity. Also it is not necessarily constant in magnitude.

c. No, we don't know that the acceleration is not constant in magnitude because increasing speed does not give enough information. We do know that the direction of acceleration is constant.

d. The speed is increasing, but do we know whether or not the acceleration is constant in magnitude?

11. In the special case in which the average velocity is equal to the instantaneous velocity for every constant A. The motion must be:

    a. Constant-speed motion in a circle.
    b. Straight-line motion, but not necessarily constant speed
    c. Straight-line uniform constant speed motion
    d. hint

(ca) c. Correct, it is a straight line because the direction as well as the magnitude of the velocity is constant.

a, b. Wrong, the speed must be constant if average velocity equals instantaneous velocity at each point. Try again.

d. If there is no component of acceleration its direction changes? Average velocity can only be equal to instantaneous velocity at each point if instantaneous velocity is constant.

12. If acceleration has only a component parallel to velocity, the resulting motion will be:

    a. circular at constant speed.
    b. curved, with varying speed.
    c. Straight line with varying speed.
    d. hint

(ca) c. Yes, because this component of acceleration changes speed only, not direction.

a, b. Wrong since there is not a component of acceleration perpendicular to velocity, the motion cannot change. Now answer correctly.

d. If there is no component of acceleration perpendicular to the velocity, can its direction change?

This about wraps up the subject of vectors. The next lesson will deal with matter and its states, and has an interesting movie to go with it. The reading assignment is sections 3.4 and 3.5 in Van Name. I'll see you then. Sign off now.

Lesson 5

Textbook Quiz

1. Zero degrees in the absolute temperature scale (Kelvin) corresponds to ________ degrees celsius (centigrade).

(ca) -273^{o}

That's right; pretty cold, isn't it? Let's try another question.

(wa) No, 0^{o} K = -273^{o} C.

hint This is one of those things you'll just have to memorize.

2. When using the ideal gas law, temperature must be measured in the ________ scale.

(ca) Kelvin or absolute.

Very good.

(wa) Wrong. In order for the formulation of the ideal gas law to work, temperature must be measured in the absolute scale.

3. The triple point of a phase diagram occurs at that temperature and pressure at which:

a. All the material will be a gas at higher temperatures.
b. The solid, liquid, and vapor pressures exist in equilibrium.
c. Absolute zero and high pressure.
d. hint

d. The name "triple point" is a clue.

(ca) b. Very good. I'm glad that you look at the diagrams in your text.

a, c. Wrong. Answer b is the correct one. Let's go on.

4. The main reason for using ice in a cool drink rather than cold water is:

a. because it floats
b. because of the heat of fusion; a chunk of ice takes up a lot more heat than the same volume of cold water.
c. because ice dilutes the drink less.

(ca) b. Very good. Scotch-on-the rocks, anyone?

a, c. Remember that it takes about 80 calories per gram to change ice to water at 0^{o} C.

5. Brownian motion which is the result of molecular motion is seen by observing:

   a. a steamship in dry dock.
   b. smoke particles under a microscope.
   c. a burning match.
   d. hint.

(ca) b. Good.

   a. No. Browning motion is observed only in very small particles.

   c. No. It is true that a lot of molecular motion is involved when a match burns, but just by looking at a match you cannot see Brownian motion.

   d. Make an appropriate choice.

You've done fine on this quiz, so you're ready to go on. Go listen now to lecture 5 on matter and its states (solid, liquid, and gaseous).

<u>Warn</u>

It's up to you whether to go ahead with lesson 5 on solids, liquids, and gases, or to reread the assignment and retake this quiz. If you want to proceed, go hear the lecture now. If you prefer another try at the quiz first, review the reading assignment and indicate "retake quiz" when you feel you're ready.

continue retake quiz

<u>Stop</u>

You haven't performed well enough to convince us that you know the material adequately. Sign off and try again after you've reread the material.

Here's your quiz on the film "Crystals." Let's see how much you remember. The main points of this film are:

1. Crystals are made of many small UNITS, ALL ALIKE.

2. These units are arranged in a regular array. Crystals grow natural plane faces peculiar to various substances.

1. How does a physicist define a solid?

   a. It is a crystalline material.
   b. Its atoms are randomly arranged and free to move.
   c. Hint.

(ca) a. Yes. This is what the physicist means by a solid.

   b. The orderly characteristic arrangement of its atoms, or crystallinity of a substance makes it a solid to physicists. Try again.

   c. Are the atoms in a solid free to move?

Mr. Holden used pennies and small cubes to represent atoms or molecules, showing the characteristic _________ that can be formed between the natural faces of similar crystals.

(ca) Angles.

Excellent.

(wa) The angles are a convenient way of describing the shape of a crystal. Type angles now.

hint. The _________ between faces of a cube are 90^{o}.

Further evidence for the regular array of atoms in crystals is the fact that cleavage will take place only in certain directions. What would happen if you attempted to cleave a crystal in some other direction? The crystal would break up before it would cleave in any direction other than the preferred one (or ones). Suppose that a solution of salol is seeded with alum crystals. What happens?

(ca) Nothing.

Exactly.

(wa) Exactly nothing happens because they're not the same compound.

hint. Choose one: crystal formation, or nothing?

This completes the film quiz. Now go hear the remainder of lesson 5.

ready to continue

The following review will cover topics covered in this lecture. Let's proceed.

1. A cotton string, containing atoms of carbon, hydrogen, and oxygen is a:

   a. molecule
   b. collection of molecules
   c. crystal
   d. hint

a. Wrong. Cotton is a fiber made out of many cellulose molecules.
c. No, a cotton string is not a crystal. Have you ever seen anyone's cotton shirt cleave along characteristic planes? Now answer correctly.
(ca) b. Good.
d. Have you ever heard of anyone growing a cotton crystal?

2. Brownian motion, which is the result of molecular motion, is seen by observing a:

   a. Steamship in dry dock.
   b. Man afflicted with St. Vitus's Dance.
   c. Smoke particle under a microscope.
   d. Match burning
   e. hint.

(ca) c. Good.

a. No. Brownian motion is observed only in very small particles.

b. Sorry. St. Vitus's Dance is a nervous disease called chorea.

d. No, it is true that a lot of molecular motion is involved when a match burns, but just by looking at a match burn, you cannot see Brownian motion.

e. Brownian motion is usually observed only in very small particles. Now answer correctly.

3. Molecules are composed of ________.

(ca) atoms.

Correct.

(wa) Atoms chemically bonded together form molecules. Now type atoms.

hint What is smaller than a molecule?

4. How would you know by direct observation that there are more than 50 molecules of water in a teaspoonful of water?

a. Water molecules are transparent.

b. Fifty particles that compose a one teaspoon volume could easily be felt.

c. No. No molecule is that big.

d. Hint.

c. No. Molecules are that big. We can think of high polymers such as polyethylene as being a single molecule. In other words, your polyethylene wastecan, in effect, can be thought of as one big molecule.

a. You could feel them, couldn't you?

(ca) b. Very good.

d. Fifty grains of sand will just begin to fill a teaspoon.

5. If the temperature of a gas is increased but its volume is kept constant, the pressure it exerts on the walls of the container will:

a. increase
b. remain the same
c. decrease
d. hint

(ca) a. Very good.

b, c. Wrong. As the temperature of the gas is increased, if the volume stays constant, the average speed of the molecules is increased and more molecules collide with the container walls in a given time.

d. Pressure varies directly as temperature when volume is kept constant.

6. A gas at 20° centigrade and a pressure of 10 newtons per square meter is contained in a 40 liter volume. If the temperature is kept constant and the volume is increased to 80 liters, the pressure will be ____ newtons per square meter.

a. 5 b. 10 c. 20 d. hint

(ca) a. That's right; if the temperature remains constant, the pressure varies inversely as the volume for an enclosed gas.

b. No. The pressure will change when the volume is changed if the temperature remains constant. Now try again.

c. Wrong. Remember that pressure varies inversely as volume. Try again now.

d. The pressure of a gas varies inversely as the volume.

7. A closed container of oxygen at 27° C. and a pressure of 30 newtons/square meter, has an average molecular speed of 19 meters/second. The container is placed in a freezer until the average molecular speed is reduced by 1/2, the pressure is:

a. more than before
b. less than before
c. 30 newtons/square meter
d. hint.

(ca) c. Good. The average molecular speed decreases with temperature, thus, the pressure on the container walls decreases.

a, b. No.

d. A gas temperature is a measure of its average molecular speed. Also, the pressure on the container wall is a function of the velocity of the gas molecules striking it. Thus, when molecular velocity decreases, the pressure decreases. To simplify, we say that pressure varies directly as temperature. Now pick the correct response.

This completes lesson 5. You should read section 5.6 for next time. Please sign off now.

Lesson 6

Textbook Quiz

1. Write the relationship between the angle of incidence i, and the angle of reflection r, for light being reflected from a plane surface (use algebraic terms).

(ca) $i = r$; $r = i$

Very good; I'm sure you also remembered that the incident and re-reflected rays as well as the normal to the surface all lie in the same plane

(wa) No, the law of reflection says that the angle of incidence is equal to the angle of reflection, or $i = r$.

2. When an image has right and left sides reversed, it is called a/an ________ image.

a. inverted
b. virtual
c. perverted

(ca) c. That's right.

a, b. Wrong, an image with right and left reversed is a perverted image. Let's continue.

3. To a good approximation, all parallel rays which strike a converging lens, then pass through a single point on the other side of the lens. This point is called the ________ of the lens.

(ca) focus; focus point; focal point.

Great, you've probably used a magnifying lens to focus the sun's rays to burn a hole in paper. You found the focus by adjusting the distance from lens to paper, for the brightest, clearest spot.

(wa) The answer is focus.

4. The image you see in an astronomical telescope is:

(ca) Right side up.

You're right again; wonderful!

(wa) Bust! The image is inverted.

Good.

Your performance just now was fine, so you are ready to proceed with the lesson, "Introduction to Optics."

Warn

Your performance indicates that it might be profitable for you to take this quiz over, after rereading the material. If you wish to do this, sign off now. If you want to go ahead with the lesson, do not sign off yet. Choose one of the following:

retake quiz continue

If you wish to do this, review the assignment now and then indicate "retake quiz." If you want to go ahead with the lesson, indicate "continue."

Stop

Sorry, you'll have to do better than that. Sign off and come back after you've reread the material and know it better.

Film Introduction

Now for the first time we're getting into real physics. The study of light and its properties is very valuable to the total understanding of this course. You will now see a film that is concerned with the question of whether or not light travels in straight lines. After some demonstrations to show that light can be bent, various types of bending (reflection, refraction, scattering, and diffraction) are demonstrated. This film is in color and is quite enjoyable.

ready to continue

Ask the proctor for film 201, "Introduction to Optics." After you have viewed it, come back here and indicate "ready to continue" for a brief film review.

ready to continue

The following four questions will test your understanding of the film you just saw.

Film Quiz

1. This film opened with a discussion of shadows. Some were sharp; others, such as the shadow of the earth on the moon, were fuzzy. This type of fuzziness is due to:

   a. diffraction
   b. refraction
   c. large size of the light source
   d. hint

(ca) c. Right. The sun is such a large source that light rays from different parts of the source throw a shadow of the earth's edge in different positions, so that the shadow of the edge is not sharply defined.

d. The sun is very large.

a. No. It is important to distinguish between the effects of diffraction and the fuzziness due to the fact that the light source is not small.

b. No, refraction is the bending of a light ray as it goes from one medium to another. Except for a short trip through the earth's atomosphere, the sun's rays travel through vacuum.

2. The sharpness of the shadow of an opaque object illuminated by a small source is evidence for the straight-line propagation of light. However, the film illustrated four ways in which light can be bent. Type the name of the method of bending that is exemplified in each of the following cases: (or type "hint")

   a. The beam of light from movie projector can be seen in a smoky room __________.

(ca) scattering.

Correct.

hint The light is scattered. Type in the name of the method of doing this.

(wa) Since the beam is projected at the screen, how does some of the light from the beam get bent toward your eyes as you view the beam from one side?

3. A fish-eye view from beneath the surface of a lake of a frog sitting on a stick above the water is dependent upon __________.

(ca) refraction.

Very good!

(wa) The light ray from the frog to the fish's eye has to go from air into the denser medium water.

(wa) The light is refracted. What method of bending light is this?

(wa) The answer is refraction. Type that in now.

4. While driving in heavy traffic on a summer day, you are temporarily blinded by the __________ of the sun shining on a nearby car.

(ca) reflection.

That's right.

(wa) Some of those cars were as shiny as a mirror.

(wa) The light was reflected. Now enter the correct answer.

(wa) Reflection is the answer. Type it now.

5. In the film, when the tongue depressors were brought very close together, light and dark bands began to show between the depressors as well as in the shadow itself. This is caused by which phenomenon?

(ca) diffraction.

Good.

(wa) The particle model cannot explain these bands.

(wa) The correct answer is diffraction. Enter that.

6. To sum up, four ways of bending light were described: reflection, refraction, diffraction, and scattering. Of these four, three depend on the interaction of light and matter, and therefore on the physical properties of the materials employed. One method of bending does not depend on the material involved. Which one? ______________.

(ca) diffraction.

Very good!

(wa) This was the method demonstrated by the tongue depressors. Do you remember what that was?

(wa) Guess you didn't remember. The concept is diffraction. Please enter that now.

This completes your quiz on the film, "Introduction to Optics." Now you should go and listen to the text of lecture 6. There is some supplementary material to go with this lecture. Have it ready, in order to better follow the discussion. When you're finished with the lecture text, return to the terminal to work through the review quiz. Sign off now.

Here are some questions on the optics subjects we discussed in the lecture just now. See how well you can do.

1. When you glare at yourself in the mirror in the morning, the image you see is:

   a. virtual b. real c. inverted d. ugly e. hint

(ca) a. That's right. Aren't you glad that it's not real?

b. No. The image you see is not real because it cannot be focused. The fact that the image appears to be behind the mirror should tell what it is. Try again.

c. No. The image you see has the hair on top, not on the bottom, so it is not inverted.

d. Speak for yourself. Now get serious and type the correct answer.

e. That the image cannot be focused should tell you something.

2. When the eye sees light rays which appear to emerge from an object as far behind a plane mirror as the actual object is in front, this image is known as a/an _________ image.

   a. real b. virtual c. inverted d. hint

(ca) b. Correct.

a. Wrong. When an image is real, the rays actually do pass through the image point. Can these rays really reach the image?

c. No, when an image is inverted, it is upside down compared to the real object.

d. A real image may be focused on a screen.

3. An object 4 cm. tall is placed 12 cm. in front of a plane mirror. The virtual image you see is _____ cm. tall, and _____ cm. behind the mirror.

a. 4, 12   b. less than 4, 4

c. less than 4, 12   d. 2, 6   e. hint

c. No, you're right about the distance behind the mirror, but the height of the image is not less than 4 cm.

(ca) a. Good.

b. No, try tracing the paths of a few light rays. The image will be the same size as the object, but will be more than 4 cm. behind the mirror. Answer again.

d. Wrong. The image will be more than 2 cm. tall and more than 6 cm. behind the mirror. Try again.

e. Remember that a virtual image from a plane mirror appears as far behind the mirror as the image is in front of it.

4. The reason you cannot read what is printed on a page when the printing is reflected from a plane mirror is the image is ____________________.

a. real   b. virtual and inverted

c. virtual and has right, left reversed

d. real and has right and left reversed

e. hint.

(ca) c. Good.

a. Wrong. The image cannot be focused and lies behind the mirror. Therefore it is not real.

b. You are correct in thinking that the image is virtual; however, the image is not inverted (up-side-down). Now answer correctly.

d. You are partially correct. The right and left sides are reversed, but the image formed by a plane mirror is <u>not</u> a real image. Now answer correctly.

e. Imagine you are looking at your image in a mirror and you wriggle your right ear. Think what ear will your image wriggle back at you? Now answer the question.

5. The image formed by a parabolic mirror of an object beyond the focal point of the mirror is _____ and _____.

a. real, inverted
b. real, upright
c. real, virtual
d. virtual, inverted
e. hint.

(ca) b. Very good.

a. You are partially correct. The image is real, but it is not upright. Draw a ray diagram (tracing the paths of a few light rays), and then answer correctly.

c. Wrong. Think for a moment about a real image. You know that a real image can be focused on a white card. A virtual image cannot be focused. Now how can the same image be both real and virtual? Draw a ray diagram and then answer correctly.

d. No. The image will be inverted, but a parabolic mirror can be used to focus an image. What do these facts tell you about the type of image? Try again.

e. Draw the ray diagram.

6. Remember that the index of refraction of a substance is expressed by:

sin i/sin r = index of refraction

If the index of refraction for a diamond is 2.5 and a ray of light strikes a face (or facet) of this diamond with a 30° angle of incidence, what is the value of sin r? (sin 30° = .50).

____

(ca) .20
.2
0.2

Excellent. In case you're interested, the angle r = 11.3°.

(wa) We're not trying to find the angle r, but only the value of sin r. Simply sibstitute values in the relationship and solve for sin r. Now type your answer.

hint Sin r = 0.2. Type that value now.

(wa) Follow this: index of refraction = sin i/sin r. We're given: i = 30°; hence, sin i = sin 30° = .5 and we're also given: index of refraction = 2.5 substituting: 2.5 =.5/sin r; sin r = .5/2.5. Now what is the value of sin r?

7. Now what is the ratio sin i/sin r called? _____________

(ca) Index of refraction.

That's right. Let's continue.

(wa) Snell's Index.

True, at least in the sense that the index was formulated by Snell, but it does not ordinarily carry his name. It is the index of something.

(wa) Refraction.

That's only part of the correct answer. When we speak of "refraction" we speak of the physical phenomenon itself. This ratio is the ______ __ refraction.

hint The ratio sin i/sin r is called the index of refraction. Now type in the correct answer.

8. When light is refracted upon entering a material from air, it is true that:

a. sin i = sin r
b. ratio sin i/sin r is a constant
c. refraction index = sin r
d. light speed doesn't change
e. hint

(ca) b. Good thinking.

a. You may be confusing this with the laws of reflection. There is a special case where sin i = sin r, when the material's index of refraction is the same as that of air. But, if this were true, then refraction would not occur.

c. Wrong. Recall Snell's law and answer correctly.

d. Wrong. The reason light is refracted is that its speed ahas changed. Now answer correctly.

e. Recall Snell's law.

9. When a light beam enters a tank of water the following lines lie in the same plane:

a. refracted and incident rays only
b. normal to the surface and incident ray only
c. normal to the surface, incident ray and refracted ray.
d. hint.

(ca) c. Correct. This enables us to use 2-dimensional diagrams instead of 3-dimensional ones.

b,c. Wrong. They're all in the same plane.

d. The situation is analogous to that for reflection.

10. When we say light is refracted we mean that light:

a. bends around corners of a small slit.
b. bounces off a surface
c. is bent when passing from one medium into another

(ca) c. Good.

a. No, this describes the phenomenon known as diffraction.

b. Wrong. This describes reflection.

Lesson 7

Textbook Quiz

1. The particle theory of light predicts that the velocity of light is:

a. greater in water than in air

b. Less on water than in air

c. The same in water as in air

(ca) a. Very good. I'm glad that you read the assignment.

b,c. It looks like you either didn't read the assignment or you forgot this part. Let's go on.

2. Experimentation showed that the velocity of light is _________ in water than in air.

a. greater

b. the same

c. the same

d. less

(ca) b. Very good! You have a good memory.

a,c,d. That's not correct; perhaps you don't remember this part of the lesson.

3. The index of refraction, n, of a material is defined by $n = \frac{c}{v}$. Which of the following seems the best n for air?

a. 1.000 b. 2.419 c. infinite

(ca) a. That's right.

b. No. The index of refraction of air must be very close to n for a vacuum, don't you think?

c. No. If n is infinite and you know that c is finite but larger, then you must think that v for air is zero. Do you?

4. Following customs, the direction of the light ray is measured from the:

   a. plane of the interface
   b. plane perpendicular to the light ray
   c. normal line to the interface

(ca) c. Good, you remembered.

a. No, this is an arbitrary choice and, so something you must remember.

b. No! This makes no sense at all. The angle would always be 90 degrees.

5. The index of refraction, n, of a given material:

   a. is constant under all conditions
   b. is smaller than one for the liquid form of the material.
   c. varies slightly with the wavelength used.

(ca) a. Very good. This is known as dispersion. Rainbows are the result of the dispersion of light by water droplets.

c. No, it varies with wavelength. Read about dispersion in your test.

b. No, if n were smaller than one, it would mean that light travels faster in the liquid than it does in empty space.

Good

Your good performance on this quiz indicates that you're ready for the next step, so go listen to lecture 7 which deals with the speed of light and a light-particle theory once proposed by Newton. When you are ready to review this material, come back here.

press to begin lecture quiz

Warn

Your performance on this reading quiz indicates that you may benefit by reviewing the assignment before going further. However, it's up to you. If you feel you're ready, go listen to lecture 7 for a discussion of Newton's particle model of light. If not, sign off and reread the material; then take this quiz over and get all the questions right. Or you can retake the quiz right now.

go to lecture quiz   retake quiz

Off

You need to reread the assignment before going on, or you won't get much out of today's lecture. Sign off and repeat this quiz when you know the material.

Lecture Quiz

1. Difficulties were encountered with the particle model of light when it was discovered that light:

   a. exerts a pressure
   b. Travels faster in a vacuum than any other medium
   c. can be reflected
   d. hint

(ca) b. Right.

a. Wrong. The fact that light exerts a pressure is compatible with the idea that light is composed of small particles traveling at high speed. Try again.

c. Wrong. Particles can be bounced off a smooth surface much as a tennis ball would bounce. Now answer correctly.

d. Remember that in refraction, light bends toward the normal when entering water from air. If light were composed of particles, this would mean that they would be going faster in the water.

2. The particle model explains diffuse reflection such as exhibited when light strikes paper by assuming the paper:

   a. is a soft surface and inelastic collisions occur.

   b. absorbs some of the particles and emits them later in random directions.

   c. Surface irregularities are larger than the light particles causing random angles of incidence thus, random angles of reflection.

(ca) c. Correct.

b. Wrong. If you turn off the light source, will the paper still emit light particles? Try again.

a. Wrong. The inelasticity would only mean some of the energy was absorbed. Try again.

d. Diffuse reflection means the light is reflected off in many directions.

3. The particle model of light assumes that light particles:

   a. are too large to be deflected by air.
   b. travel so fast we don't notice gravitational bending of their paths.
   c. travel so fast gravity can't catch them.

(ca) b. Very good.

a. No, just the opposite is true. The particle model of light assumes that light particles are extremely small. Knowing this, answer the question correctly.

c. No. Where would you run if you wanted to avoid gravity completely?

d. Does the gravitational field "chase" light particles or is it there throughout space before the light arrives?

O.K. Time for a movie now. This very interesting one is concerned with the measurement of the speed of light, both in air and in water. You will actually see how this is done, and will be introduced to the idea of a "difference" measurement, as opposed to direct measurement. In this film, the differences measured is in the lengths of the paths travelled by two different "beams" of light. It will be pointed out how the difference type of measurement eliminates certain types of systematic errors.

When the measurements have been made, it is found that light travels more slowly in water than in air. This directly contradicts Newton's particle theory, which called for light to travel faster in a denser medium.

Ask the proctor for film 203, "Speed of light." When you have finished viewing it, report back here for a review.

press to take the film quiz

Film Quiz

1. Here's an easy question. Which statement is true? The speed of light:

    a. being infinite cannot be measured.
    b. can be measured.
    c. hint

(ca) b. Right. We're off to a good start.

a. Then what was Mr. Siebert doing with all those mirrors and electronic equipment on the football field? Try again.

c. Forty lashes if you need a hint for this one.

2. In the second experiment in the film the time difference along two paths (through air and water) was made to be zero by adjusting the length of one of them. This measurement has important implications for the particle model of light, since for the particle model to explain Snell's law, we must assume that light travels faster in _________ than in _________.

    a. water/air   b. air/water   c. hint

(ca) a. Correct.

b,c. To explain the fact that a light ray bends toward the normal as it enters a medium like water the particle model requires that speed increase. Try again.

3. In the film, we saw that the speed of light in water is ________ than in air.

   a. greater　　　　　　　c. the same
   b. less than in air　　　d. hint

(ca) b. You remembered correctly.

a, c. No, remember the air path had to be longer than the water path. Therefore, the speed in water must be what compared to air, if the time to traverse the paths is the same? Try again.

d. Remember that the air path had to be longer than the water path. Try again.

4. Since the speed of light in water is less, NOT greater, than in air, the particle model of light:

   a. must be discarded　　　c. must be modified
   b. is proved　　　　　　　d. hint

(ca) c. Very good. We will take this up again later in the course, after you've learned more about mechanics and how particles behave.

a. No, this model may be too simple in its present form, but it is still useful! Try again.

d. The particle model accounts for some, but not all, of the facts.

b. No, wouldn't it be nice if this simple model could explain everything? Remember it did not correctly predict the speed of light in water as compared to air. Try again.

Your next lesson will cover the material contained in section 5.6 in Van Name. Please read it before returning.

That's all for today. Read sections 5.1, 5.2 , and 5.3 <u>carefully</u> for next time. Goodbye. Sign off.

Lesson 8

Textbook Quiz

1. Do waves carry energy?

a. yes b. no

(ca) a. How about that? Let's try another.

b. I'm sorry, that's wrong. Waves do carry energy. Let's go on.

un. The answer is yes. Let's go on.

2. Does the medium in which waves travel experience a permanent change because it transmitted a wave?

a. yes b. no

(ca) b. Very good, you're pretty sharp today.

a. You blew that one. The medium is not permanently affected. Let's try another one.

un. The answer is no. Let's go ahead.

3. Are sound · aves longitudinal, or transverse?

a. longitudinal b. transverse

(ca) c. Absolutely right.

b. Sorry, you're wrong; sound is a longitudinal wave.

un. Sound is a longitudinal wave.

4. The time it takes for two successive crests (or troughs) of a wave to pass a given point is called the:

a. frequency c. period
b. speed d. amplitude

(ca) c. Very good! You've read your assignment.

a,b,d. Wrong. The correct answer is "period."

5. The type of wave in which the vibrations of the material are perpendicular to the direction of motion is called:

a. transverse c. round
b. longitudinal

(ca) a. Good for you!

b,c. No, this kind of wave is a transverse wave.

Good

Good work; you're ready now to proceed with lesson 8 on waves. You'll also see a movie on this subject. Go listen to your lecture now.

press to take film quiz for lesson 8.

Stop

You need to review today's reading assignment before going any further. Review the assignment, and then take this quiz over when you think you can do better.

Warn

You could stand to take this quiz over. If you want to do that, sign off now, reread the material, and then come back. If you want to go on, though, listen to lecture 8 on waves, or you may retake the reading quiz now.

press for film quiz, lesson 8

press to retake reading quiz 8

Film Quiz

1. A "slinky" (large-diameter steel spring), a small-diameter brass spring, and a rubber tube each have one end attached to a cross-bar held in the experimenter's hand. (This enables him to launch a pulse on all three sides simultaneously.) When he moves the bar in his hand, a wave pulse is sent down the three "media" and is reflected back from the stationary bar. Which of the following is correct?

    a. Waves on all three got back to the bar in his hand at the same time.

    b. The waves died out before getting back to the bar.

    c. The three waves got back at different times.

    d. Hint.

   d. The speed with which a wave travels (known as the speed of propagation) depends very much upon the material the wave is traveling in.

(ca) c. That's right.

a,b. No, the three waves got back at different times.

2. If two identical "slinkies" are used, do the wave pulses get back at the same time or different times?

    a. same   b. different   c. hint

(ca) a. Correct.

b. No, they get back at the same time. Now type the correct answer.

c. The two "slinkies" are made of the same material, aren't they? Now answer the original question.

un. Type same or different.

3. In the next example, the experimenter took up a few turns of one of the slinkies in his hand, making this one tighter than the other; the result was:

   a. The wave pulse traveled faster on the tighter slinky.

   b. The wave pulse traveled slower on the tighter slinky.

   c. The speed was the same on both slinkies.

   d. Hint.

(ca)a a. You have a good memory. But why did this happen?

c. No, the speed was different on the two slinkies. Try again.

b. No, it traveled faster on the tighter slinky, but the main point is that the speed was different on the two springs. Now enter the correct answer.

d. The tighter slinky is no longer the same medium as before; it has been deformed by stretching. What will this do to the speed of the wave pulse?

4. This time a single coil was used. A rotating switch triggered flashbulbs so that photographs were taken of the progress of a wave pulse down the coil of intervals of 1/20th of a second. Six positions were photographed against a measured table, so the distance traveled by the pulse in each successive interval could be measured.

   In the situation just described, it was found that the pulse:

   a. Decreased in speed as it progressed along the coil.

   b. Split into a number of components.

   c. Traveled equal distances in the equal time intervals.

   d. hint.

(ca) c. Yes.

a. No, the distance traveled in one interval was the same all along the path. The amplitude, or size of the displacement, decreased slightly as it progressed.

b. No, the wave shape remained essentially constant. The six pictures showed differently located peaks, but these were all the same wave, photographed in different positions.

d. Think of the reasons underlying the correct answer to the previous question.

5. It's important to remember that the generalizations in this film concerning wave properties apply only to waves of small amplitude. For very large amplitude, they hold only approximately.

The last experiment was to see what happens when a wave goes from one medium to a second medium in which the speed is different. Dr. Shive used two torsion-bar machines whose cross-bars were of two different lengths, and connected them end-to-end. A wave pulse started on pne end of the faster medium was transmitted through the boundary to the second medium. The pulse moved more slowly in the second medium.

Dr. Shive repeated the experiment so that you would notice something else of importance that happened. What else besides transmission happened to the wave at the boundary between the two media?

a. partial reflection
b. nothing
c. secondary refraction
d. hint

(ca) a. Good.

b. Wrong, something did happen. What was it?

c. You weren't watching closely. Try again.

d. This was something you could easily observe.

That's all for today's film quiz. Go and hear the remainder of the lecture now.

press for lecture quiz 8.

Lecture Quiz

1. Suppose we generate periodic waves at a frequency of five waves per second, and the distance between crests is three meters. The wave's speed is _______ meters/second.

a. 15 b. 1.33 c. 0.6 d. hint

(ca) a. Very good; you remembered that v = fL.

b, c. No, remember that v = fL, or velocity equals frequency times wavelength.

d. Remember that v = fL, or velocity equals frequency times wavelength.

2. A train of periodic waves with a period of 3 seconds travels in a medium in which its wavelength is 18 centimeters. Its speed in this medium is _______ cm/sec.

   a. 6   b. 54   c. 1/6   d. hint

(ca) a. Good.

b,c. Wrong. Try again.

d. What is the relationship between period and frequency?

3. The wave train in the previous question enters a second medium in which its speed is 4 cm/sec. Its wavelength in the second medium is _______ 18 cm.

   a. less than   c. greater than
   b. equal to   d. hint

(ca) a. Right; you found the wavelength from:

$$L/T = \text{speed}$$
$$L/e \text{ sec} = 4\text{cm/sec}$$
$$L = 12 \text{ cm.}$$

b. Wrong. The wavelength must change when entering the second medium because the period remains the same.

c. Wrong. Use the relationship L x ? = speed to solve this problem. (Remember that f = I/T). Try again.

d. Use the relationship L x F = speed. (Remember that f = I/T).

Lesson 9

Textbook Quiz

1. Can particle streams interfere destructively?

   a. yes b. no

(ca) b. Very good.

a. Wrong. Particles can interfere constructively, but not destructively.

un. Type yes or no.

2. If two waves of amplitude one meter are in phase when they cross, what is the maximum observed amplitude in the area of crossing? (Type a numeral and the proper units)

(ca) 2 meters.

If you answered 2 meters, and I think you did, that's right. This is an example of constructive interference.

(wa) Wrong. If the two waves are in phase, they will interfere constructively with a resulting amplitude of 2 meters. Type 2 meters.

3. Double slit interference patterns showed that light has the characteristics of a _______ phenomenon.

(ca) wave.

You're sharp today.

(un) Wrong. This type of interference observed indicates that light has wave characteristics.

4. If a narrow beam of light passes through 2 closely adjacent slits simultaneously and then illuminates a screen, you would expect to see:

   a. a uniformly illuminated screen.

   b. an irregularly illuminated screen with no recognizable pattern.

   c. a screen with illumination in bright and dark bands.

(ca) c. You're right. This is how Young first showed that light was a wave phenomenon.

a. Wrong. What about interference?

b. Wrong. If you don't believe chapter 5.4 in your text, maybe you should try the experiment yourself.

Good

Very good. You're ready to proceed to lecture 9, a continuation of the wave model of light. Sign off now and go listen, Don't forget to have your supplementary material handy.

Warn

If you think you should go on, get the supplementary material for lecture 9 and then dial.

Stop

You'll have to reread the assignment and then take this quiz over; you simply didn't do well enough to pass. Sign off now.

Second Try

All right, go ahead and dial lesson 9 (get out your supplementary material, too). And please be better prepared for the reading quiz next time. Sign off now.

Here are a few questions on what you've just had in the lecture. See how well you can do.

Lecture Quiz

1. If two equal wave trains are 1/2 period out of phase when they cross in a medium, the displacement of the medium at the point of crossing will be ______ what it would be for one of them.

   a. 1/2 b. twice c. four times d. zero times

   e. hint

(ca) b. That's right. This is called destructive interference.

a. Wrong. Remember that we are considering two equal wave trains which are out of phase, Now answer correctly.

c,d. Wrong. Remember that the wave trains are out of phase, not in phase. Now answer correctly,

e. Recall a diffraction pattern; the dark bands are results of out-of-phase wave trains crossing. Now answer correctly.

2. When two light waves meeting in a medium are "in phase,"

   a. They cancel each other out.
   b. Their wavelength must be unequal.
   c. They interfere constructively.
   d. They do not interfere
   e. Hint

(ca) c. Correct. This is called constructive interference, or reinforcement.

a. No. If two light waves are in phase, they do the opposite of cancelling each other out. Try again.

b. Wrong. You may be confusing this question with the relationship $T = 1/f$. Remember what "in phase" means, and answer correctly.

d. Wrong. When waves are in phase they reinforce one another. Now try again.

e. Diffraction patterns are evidence for light being in and out of phase in certain areas. Now try again.

3. Reflection, refraction, and diffraction:

   a. Can all be explained by the particle model of light.

   b. Can all be explained by the wave model of light.

   c. Are all independent of wavelength.

   d. Do not result in the bending of light.

   e. Hint.

(ca) b. Correct

a. No, the particle model of light cannot easily explain diffraction.

c. Wrong. Remember that refracted blue light bends more sharply than refracted red light. This is the principle of the spectrum produced by a prism from white light. Now answer correctly.

d. Absolutely wrong. Reflection, refraction, and diffraction are all examples of the bending of light. Now look over the choices and answer correctly.

e. One of the light models cannot explain diffraction. Now make a choice.

4. Diffraction:

   a. is related to interference.

   b. of light can be observed only with very wide slits.

   c. results in sharp shadows of small objects.

   d. hint.

(ca) a. Correct. Constructive and destructive interference produce the light and dark areas which characterize diffraction.

b. Wrong. Let's try a short experiment. Close one eye and focus the other at a light source. Now arrange your thumb and forefinger so that you can see the light source between the two. Continue looking at the light source and bring your fingers together and observe what happens.

c. No. Diffraction doesn't cause shadows of small objects to be sharp. Diffraction is seen as bands of light and dark areas when light shines through small openings.

d. Diffraction is seen as light and dark areas when light goes through very small openings.

5. Using the wave model of light, which way would you predict the refracted beam would bend when light goes from glass to vacuum?

a. Toward the normal

c. Out of the plane in which the normal and incident beams lie.

b. Away from the normal.

d. Hint.

(ca) b. Good. The beam bends away from the normal when it goes from a dense medium to a less dense one.

a. Wrong. Remember that the beam is passing from a dense medium to a less dense one. Try again.

c. Wrong. Remember the rule of refraction. The incident beam, refracted beam, and the normal to the surface all lie in the same plane.

d. Light bends toward the normal when passing from vacuum to glass. Now what will it do when passing from glass to vacuum?

6. When periodic waves pass from one medium into a dense one, their

a. frequency decreases
b. speed decreases
c. wavelength does not change
d. hint

(ca) b. Right; the frequency remains the same, but the speed decreases.

a. No, the frequency remains the same. Try again.

c. Wrong. The wavelength actually decreases as the wave passes into a denser medium. Now answer correctly.

d. Remember what happens to the speed of light when it enters water from air. Answer again.

7. According to the superposition principle when two sound waves of different sizes cross in air, the:

   a. waves do not interfere.
   b. net displacement of the air is the sum of the individual displacements.
   c. larger wave will absorb the smaller one.
   d. hint.

(ca) b. Excellent. Let's continue.

a. No, since both waves displace the a , they are bound to interfere with one another. Try again.

c. No. The displacement of both waves, added together, determines the net displacement. That is, the effect of the smaller wave is not lost or neglected.

d. The net displacement is the sum of the two wave displacements.

That's all for lesson 9. Next time we will begin the study of forces. Please read section 2.5 in your text in preparation. You may sign off now.

Lesson 10

Textbook Quiz

1. Is force a vector quantity?

   a. yes   b. no

b. No, no, no! Force is a vector! It certainly has a direction.

un. The correct answer is yes.

(ca) a. Wow! Good.

2. State Newton's second law in algebraic terms. (Let a = acceleration, m = mass, and F = force).

(ca) $F = ma$

Very good. This is an important law, basic to classical physics.

un The second law of motion is written as $F = ma$. This is one of the most important formulas in physics.

3. Keeping in mind Newton's second law of motion, you cause a body to accelerate with an acceleration, a, by applying a force, F. You can measure F and a. Find an expression for the mass, m, of the body.

(ca) $m = F/a$.

Excellent. Perhaps you should be a physics major.

un Wrong. Solving $F = ma$ for m, we get (by dividing both sides by a) $m = F/a$.

4. In the metric system, the unit of force which will give a mass of one kilogram an acceleration of $1 m/sec^2$ is called the ________.

(ca) newton

Excellent.

un Wrong. This unit is called the newton.

Good

You've passed this quiz with flying colors, so you're ready to proceed to today's discussion on forces.

Warn

If you think your performance was satisfactory on the reading quiz, then you may now listen to lecture 10 on forces. Have your supplementary material ready, too. If you are not satisfied with your performance, you may either sign off and reread the material or take the test again right now.

press to retake quiz

press to take lecture quiz 10

Stop

You didn't do well enough this time to go on. Please read your assignment again, and come back when you think you know it. Sign off for now.

Here are a few questions on the lecture you just heard.

1. A body is moving in a circular path with constant speed. The body's acceleration:

   a. points toward center of circle
   b. points away from center of circle
   c. is parallel to its velocity
   d. is zero
   e. hint

(ca) a. Correct.

b. You're on the right track, but you've got your directions exactly reversed.

c. Wrong; try again.

d. No; remember its <u>direction</u> is changing.

e. Acceleration perpendicular to a velocity changes its <u>direction</u> but not magnitude.

2. Four monkeys are playing with a chair. Monkey A pulls the chair north with a 15-newton force, B pulls it west with a 35-newton force, and d pulls it east with a 25-newton force. In what direction will it be accelerated?

a. Southwest   b. Southeast   c. West

d. It will not be accelerated   e. hint

(ca) a. Very good.

b,c,d. No; acceleration involves unbalanced forces, so analyze the unbalanced forces in this problem and try again.

e. Find the net north-south and net east-west force. What is the resultant?

3. If an object is at rest, we can conclude that:

a. Gravity is holding it down.
b. No forces are acting on it.
c. No net (unbalanced) force is acting on it.

(ca) c. Very good. You have grasped a very important point.

a. No. There are other forces acting on it.

b. Not necessarily. Think carefully and try again.

d. What have we said about net, or unbalanced, forces?

4. An object of mass 50 kg. is moving with an acceleration of 2 m/sec^2 north. (Remember from your reading assignment that F = ma.) Four forces are acting on the body. Three of them are: 250 nt. north, 75 nt. east, and 150 nt south. The fourth force must be:

a. 100 nt south   c. 130 nt north
b. 75 nt west   d. hint

(ca) b. Good.

a, c. Wrong; if the object is accelerated north, the unbalanced force must be in a northerly direction only.

d. Since the acceleration is north, the unbalanced force must be due north.

Read section 2.5 again for the next lesson, especially the parts about Newton's second law. Please sign off.

It's movie time now. Today's film is concerned with forces. It is pointed out that only three basic types of electrical forces really exist: These are: gravitational, electrical, and nuclear. Their relative strengths are pointed out and some demonstrations are given. One of these is a repeat of the famous Cavendish experiment. It is a fact that any given body in the universe exerts a force on any other body (this may come as a shock to you!), and the Cavendish experiment is designed to demonstrate this force between such a pair of objects (a bag of sand and a bottle of water, in this case). The kind of force involved in this experiment is gravitational force.

Some demonstrations are also given to stress the fact that forces always involve at least two bodies; the body (or system) doing the pushing, and the body being pushed.

You can get a lot out of this film if you pay close attention. Go now and ask the proctor for film 301, "Forces." Then come back here and we'll check how much you've learned.

Now for a few questions on the film, "Forces." Let's see how much you can recall.

<u>Film Quiz</u>

1. What are the basic forces in nature? (Choose from among the following):

   a. electric
   b. magnetic
   c. inter-atomic
   d. gravitational
   e. contact
   f. nuclear

   a. a and d
   b. a,b,c, and e
   c. a, d and f
   d. all of the above

(ca) c. That's correct.

a. That's close, but you forgot one. Try again.

b,d. There are three basic types; try again.

2. The force between two magnets, or forces of electromagnetic origin would be classified as which of the three basic forces?

(ca) electrical.

Yes, forces of electric, magnetic, or electromagnetic origin are lumped together under the term "electrical."

(wa) No, that's the force between two masses. Try again.

(wa) No, the magnets cannot get close enough together for nuclear forces to operate.

hint The word "electromagnetic" is a clue.

(un) If you're having problems, ask for a hint.

(un) The answer is electrical.

3. When the Cavendish experiment was performed to show the universality of gravitational attraction , the box containing the bottles had to be enclosed by screens in order for this demonstration to be effective, because gravitational forces are relatively weak compared to ________ forces.

(ca) electrical.

Right. Without screening, stray electric fields would affect the pendulum, and obscure the effect of the gravitational attraction.

(wa) No, the screening wouldn't have helped much if nuclear forces had been released.

(un) Answer electrical or nuclear.

hint Electrical or nuclear?

4. In the Cavendish experiment the sand box had to be very close to the water bottle to cause a measurable force. The deflection of the electron beam in the cathode-ray tube increased as the magnet or the charged rod was brought closer. Nuclear forces are contained within a small fraction of an atom's diameter. So these three types of forces have one thing in common, they all depend on

____

(ca) Distance
(cb) Length
((cb) Separation
(cb) Closeness
(cb) Nearness

Good.

hint The pull between two magnets for example, depends upon the ______. between them. Type in the word.

(un) The answer is distance. Type that now.

5. At the end of the film, two small carts collide on a track. Then one cart is fastened down and covered with a close, and the other cart is made to collide with it. How many bodies are involved in the force of this collision?

a. one b. two c. hint

(ca) b. Right. The point is that a force always involves at least 2 bodies.

a. No; a force cannot involve just one body.

hint Though the fastened-down cart does not move, it still experiences a force.

This concludes your film quiz. For next time, reread section 2.5 in Van Name. I'll see you then.

Sign off please.

Lesson 11

Textbook Quiz

1. An object that has acting on it only 10 newton force up and a 10 newton force down:

   a. accelerates at right angles to the interforce line.
   b. remains at rest if it was originally at rest or moves in a straight line with constant velocity if originally in motion.
   c. revolve in a circle about the interforce axis.

(ca) b. That was rather obvious, wasn't it?

a, c. Wrong. Add the forces vectorally and note the net force is zero so there cannot be any acceleration of any kind.

2. What is the acceleration due to gravity at a point near the earth's surface?

   a. 9.8 m/sec   c. 10 m/sec
   b. 12 ft/sec   d. 9.8 m/sec

(ca) a. Good.

b,c,d. Wrong. It's 9.8 m/sec.

3. If you want to measure the inertial mass of a body you should:

   a. set it in motion with a constant velocity and see how long it moves when there are no forces involved.

   b. set it in motion under the influence of a constant force and observe its time rate change of velocity.

   c. drop it on your toe.

(ca) b. That is correct.

a, c. Wrong. If there are no forces the object will move forever. The second choice is the correct one.

4. For a certain given force, acceleration is __________ proportional to mass.

a. directly b. inversely c. sometimes

(ca) b. That is right. You're lucky to get such an easy question.

a, c. Wrong. Newton's second law reads force equals mass times acceleration. The answer is inversely.

Here are five questions on the film you just saw, "Inertia." Let's proceed.

1. In the first experiment in the film, Purcell gave the object one push, then photographed it as it slid freely across the surface with no horizontal force acting on it. The motion was:

a. accelerated c. of constant velocity
b. decreased d. hint

(ca) c. Correct. The object moved in a straight line with constant speed. We might at first conclude that an object on which no force acts moves with constant velocity.

a, b. No. The measured distance traveled by the object in each one-second interval was 16 centimeters. Now answer correctly.

d. The marker mounted on the object moved 16 centimeters in each one-second interval.

2. Is it true that after the initial push there were no forces at all acting on the puck, assuming that friction was completely eliminated by the carbon dioxide device.

a. yes b. no c. hint

(ca) b. Correct. The pressure of the escaping carbon dioxide gas pushes upward on the puck, but is balanced by the weight of the puck pushing down. The conclusion should be modified to say that an object on which no unbalanced force acts moves with constant velocity.

a. Not really, What about the pull of gravity on the object. Please try again.

c. What about the pull of gravity on the object.

3. In experiment 2, single constant force was applied by Dr. Purcell's trained assistant to the object initially at rest. What type of motion was observed?

a. accelerated c. of constant velocity
b. decelerated d. hint

(ca) c. Right, the constant force produced uniform acceleration of the body in a straight line.

b. No, decelerated motion would mean the object was slowed down. This was impossible since the body was initially at rest.

a. Wrong. Constant velocity was observed in the first experiment when no unbalanced force was acting on the body.

d. Remember the previous experiment. When no force was acting on the body, it moved with constant velocity.

4. In experiment 3, a larger constant force was applied to the object initially at rest, by attaching two identical rubber rings to it and having them both pulsed as in experiment 2. We assume that the two rubber rings exert twice the force on the object that one did in experiment 2. The acceleration, as measured by the distance in length traversed in successive one-second intervals, was ______ times as large as in experiment 2.

(ca) Two.

Correct. We conclude that the acceleration is proportional to the applied force.

un The doubled force was found to cause twice the acceleration. Please type 2.

5. This last question should be an easy one. The property of ta body which makes it resist a change in its motion is _________.

(ca) inertia.

Glad you said that.

un Weight.

Wrong. Weight is the gravitational force pulling on the object. These experiments did not involve the force of gravity.

hint Think now, what is this film all about?

This completes the film quiz. Please return to your lecture and continue now.

ready to continue

Now, let's see how much you got out of the lecture you just heard.

1. An object is moving along with an acceleration of 3 m/sec^2 under the influence of a constant force. If the force is now doubled, wha what will the new acceleration be?

a. 9 m/sec^2 c. 1/9 m/sec^2

b. 6 m/sec^2 d. 1/6 m/sec^2 e. hint

(ca) b. Right.

a,c,d. No. Acceleration is proportional to force, remember? Try again.

e. What does "a is proportional to F" mean?

2. What happens when two unequal objects are acted upon by equal net forces? Their acceleration are ______________________.

a. equal

b. directly proportional to their masses

c. inversely proportional to their masses

d. hint

(ca) c. Very good. You saw that the more massive object has the smaller acceleration, given the same force.

a. Good heavens, no! Do you mean that the same push would give a locomotive and a tricycle the same acceleration? Better try again.

b. Wrong. That means a big mass will have a higher acceleration than a small mass with the same push.

d. Think what happens when the same push is given to an eraser and a baseball bat.

3. A body is moving along with constant velocity, from this observation we can say:

a. no force is acting on the object.
b. no NET force is acting on the object.
c. acceleration is constant and nonzero.
d. hint.

(ca) b. Exactly, I'm glad you realize that it takes an unbalanced force to change velocity.

a. Wrong. Remember in the film, the puck had two equal but opposite forces acting on it, but still maintained constant velocity. Try again.

c. Acceleration is the rate of change of velocity so if acceleration was nonzero, the velocity would be changing. Try again.

d. Velocity, acceleration, and force are all vector quantities and have to be handled with both magnitude and direction in mind.

4. The inertial mass of a body can be measured by:

a. its angular acceleration when it is whirled on a string.
b. its resultant acceleration when a known force is applied.
c. balancing on a beam balance with standard masses.
d. hint.

a, c. Wrong. Angular acceleration has nothing to do with the topic at hand. Think a little and try again. That is one way of measuring mass, but that measures gravitational mass.

d. Inertial mass is the resistance to motion of an object.

(ca) b. Absolutely correct.

That's all. For next time, your assignment is to reread section 2.5 in your text. Since you've already had it before, it should be easy for you. Now sign off.

Lesson 12

Textbook Quiz

1. If you have two objects, one of mass, m, and the other of mass, M, and their respective weights are w and W, then is $\frac{W}{w} = \frac{M}{m}$ true?

a. Yes b. No

(ca) a. Yes. Good. I'll bet that you even remembered that that was on page 43.

wa, un Wrong. That relationship is absolutely correct.

hint Type yes or no.

Proctor call.

2. How do you find the weight of an object of mass m where the acceleration due to gravity is g? (Write the formula, let w = weight).

(ca) w = mg.

Right. That looks equivalent to F = ma, so that weight must be a force. Here's something to think about; if your weight is the same as a force, why aren't you being accelerated?

un Wrong. If w = weight, m = mass, and g = acceleration due to gravity, then weight of an object is found by w = mg. Commit that to memory; you'll need it in the future.

hint Proctor call

3. If you were on a planet where weight always was equal to mass, what would the acceleration of gravity be on the surface of this planet?

a. 9.8 m/sec^2 b. 980 m/sec^2 c. 1 m/sec^2

(ca) c. Right! Weight equals mass times the acceleration due to gravity but g is different on different planets.

a. 9.8 m/sec^2 for earth, not for every planet.

b. No! This sounds like you were guessing.

4. Mass can be directly measured with:

   a. a barometer

   b. a beam balance with standard reference mass

   c. an ordinary bathroom scale

(ca) b. Of course!

a,c. No. A beam balance measures one mass directly against another mass.

Good

You have done well enough to proceed directly with today's lecture, the subject of which is weight and mass.

You'll begin by seeing a film which should give you some insights into this subject.

Warn

It wouldn't hurt you to take this quiz over; your performance wasn't the greatest in the world. If you want to do that, indicate when you are ready. Otherwise, touch "continue."

retake   continue to movie introduction

Stop

You need to go back and review. Sign off now and retake this quiz when you're better prepared.

Last time you were here, we showed that acceleration of an object is proportional to the net applied force. Today you'll see a film that shows what happens when the same force is applied to different objects. The close relationship between gravitational mass (weight) and inertial mass (mass) will also be pointed out.

Now ask the proctor for PSSC film 301, "Inertial Mass." Then return to this terminal for a review quiz.

film quiz

Let's see how much you got out of this last film.

1. In "Inertia," it was demonstrated that if different forces are applied to the same object, the acceleration produced is proportional to the force. In the film , the force is kept constant and objects with different inertias are accelerated. If a = acceleration, i = inertia, the observations indicated that a is:

a. not dependent on i.

c. inversely proportional to i

b. proportional to i

d. hint

(ca) c. Correct. Two disks fastened together had 1/2 the acceleration of one disk, for the same applied force. An idea learned in the previous film: for the same inertial mass, acceleration is proportional to force, can be combined with the idea learned in this film for the same force, acceleration is inversely proportional to inertial mass, into one statement: Acceleration is proportional to force divided by inertial mass.

a,b. Wrong. Remember, two disks fastened together did not have the same acceleration as a single disk. If this were so, two disks in the film would have had twice the acceleration of a single disk for the same force.

d. With 2 disks, was the acceleration greater or less than with only one?

2. Why don't parakeet feathers and lead bricks fall through the air with the same acceleration?

a. They do.

d. hint

b. Inertial pull of gravity is stronger on lead.

c. Air resistance slows the feather down.

(ca) c. Right.

a. You've got to be kidding!

b. No, gravity is an acceleration which is the same for all objects released in the same location.

Please make a choice.

Proctor call.

d. The wind blows feathers about more easily than it does bricks.

3. Objects having the same mass always have the same weight.

a. true   b. false   c. hint

(ca) b. Good for you. That was a tricky one.

a. Wrong; weight depends upon where the measurement is taken.

Please make a choice.

Proctor call.

c. Would the weight of an object be the same on the top of the Empire State Building as in Death Valley?

Now you're ready for lecture 12 on weight and mass. Go listen to it; then report back here.

ready to continue

Here's your very last quiz . . . for the time being! Try to do well.

Lecture Quiz

1. In the mks system of measurement, mass is measured in ________ (type out complete word).

(ca) kilogram.

Right, let's continue.

(wa) Mass is measured in kilograms. Type that in.

Type kilograms.

hint What does the "k" in "mks" stand for?

2. In this system of measurement, weight is found by multiplying mass by the acceleration due to gravity. The result of this multiplication is a force. The units involved are: kg x m/sec^2. The correct name for this unit of measure is a ______.

(ca) newton.

Good. Let's use this information in some problems.

(wa) kg m/sec^2 is a newton. Type that in. Type newton.

Proctor call.

hint It's named after a very famous scientist.

3. A body has a mass of 100 kilograms on the earth. How much will the same body weigh on the moon? (Moon's gravitational acceleration is 1/6 of earth's.)

a. 16.6 kilograms
b. 163.3 kilograms
c. 163.3 newtons
d. 100 newtons
e. 100 kilograms
f. hint

(ca) c. Very good. The body has a mass of 100 kilograms on the moon and its weight there would be:

$$1/6 \times 9.8 \ m/sec^2 \times 100 \ kg = 163.3 \text{ newton}$$

a,d,e. Wrong. It's mass remains constant, but the weight changes with gravitational field.

b. You were partly right. The numerical answer is correct but your units are wrong. We are looking for weight, not mass.

e. No, its mass on the moon (or anywhere for that matter) is 100 kilograms, but we asked for the weight. Try again.

hint The acceleration of gravity on the moon is $1/6 \times 9.8$ m/sec^2 - 1.63 m/sec^2.

Proctor call.

Please make a choice.

4. A person whose mass is 75 kilograms is asleep on Miami Beach. What force does the sand of the beach exert on the person's body?

   a. 75 newtons b. 75 kilograms

   c. 735 newtons d. hint

(ca) c. Excellent! You seem to understand that mass acted on by gravity exerts a force, and in this case since the person is exerting a force down because of gravity acting on his mass and he is obviously at rest, there must be an equal but opposite force being exerted on the person to keep him at rest.

You're heading in the right direction. You realize that a newton is a unit of force, but you must remember that a kilogram of mass is not equivalent to a newton. Keeping that in mind, work the problem correctly.

a,b. No, remember that a kilogram is a unit of mass, not weight. Try again.

d. If the beach is exerting more or less force on the person's body than he is exerting on the beach, what would you expect to happen?

Please make a choice.

For your next session with me, I'd like you to read section 2.10 in your textbook. Please sign off.

5. What would be the magnitude of the acceleration of a 3 kilogram mass which is acted upon by a force of 9 newtons?

   a. 27 m/sec^2 c. 1/3 m/sec^2

   b. 3 m/sec^2 d. hint

a. No, force equals mass times acceleration. Try again.

c. No, force equals mass times acceleration; therefore acceleration equals force divided by mass. Try again.

(ca) b. Correct.

d. Don't you recall learning a very simple equation which gives the relationship between F, m, and a? I hope you do!

O. K. That's it. For next time, read section 2.10 in the text. Sign off now.

Lecture 13

Textbook Quiz

1. Centripetal acceleration is directed:

   a. along a line tangent to the circular path.
   b. away from the center of the circular path.
   c. toward the center of the circular path.

(ca) c. Wonderful. Your ready retention is high.

a, b. No, the correct answer is c. Let's go on.

2. The speed of an orbiting body is:

   a. dependent on the mass of the body.
   b. dependent on the radius of the orbit.
   c. independent of the mass of the earth.

(ca) b. Right.

a, c. No. The correct answer is b.

Please make a choice.

Proctor call.

3. If we write $G \frac{m_1 m_2}{r^2} \quad m_1 \frac{v^2}{r}$, we are equating the:

   a. electromagnetic force to the centripetal force.
   b. force of gravitational attraction to the centripetal force.
   c. force of gravitational attraction to the heliocentric acceleration.

(ca) b. You are right.

c. Wrong. The presence of m_1 and m_2 should have indicated gravitational force to you.

a. Bad guess. Try to be more prepared when you come here.

4. Can a force cause a change in direction of motion without causing a change in velocity?

    a. yes   b. no

(ca) b. Very good. You are mentally alert.

    a. Wrong. Velocity is a vector and so has a certain direction. If the direction changes, the vector changes. Velocity is a vector.

Stop

You can't go on until you've taken this quiz again and done better. Sign off now.

Warn

You didn't do as well as you might have; it wouldn't hurt you to stop here, review, and retake this quiz afterwards. However, if you think you know enough to go on, listen now to lesson 13, on deflecting forces.

retake reading quiz   proceed to movie quiz

Good

You've passed this quiz with flying colors, so you can now go listen to lesson 13 on deflecting forces.

ready to continue

Here are some questions on the film which you just saw "Deflecting Forces."

1. When a projectile is moving on its parabolic path, does the force of gravity act as a pure deflecting force on the projectile?

____

(ca) Right. In the case of a parabolic path, the force of gravity, which always points straight down is perpendicular to the velocity vector only at the apex of the path.

(wa) Wrong. The force of gravity points straight down. Is the path of the projectile at all times at right angles to the direction of gravitational force?

2. By drawing the position, velocity, and acceleration vectors on a turntable, Frank could derive an expression for the centripetal (center-seeking) acceleration in terms of the radius R and the period of rotation T. An equation for the speed, v, in terms of R and T, is ___________. (Remember, circumference = 2 pi R).

    a. (2 pi R)/T   c. T/2 pi R

    b. 2 pi RT   d. hint

(ca) a. Excellent. You could go on from there to obtain the expression for acceleration: $a = 4(\text{pi})^2\ R/T^2 = v^2R$.

c, b. No; it sounds as though you're guessing. Consider the dimensions of speed and answer correctly.

d. Speed has dimensions of distance divided by time.

2. By drawing the position, velocity, and acceleration vectors on a turntable, Frank could derive an expression for centripetal (center-seeking) acceleration in terms of the radius, r, and the period of rotation, t. Write an equation for speed, v, in terms of r and t. (Remember, circumference = 2 pi r).

(ca) v =2 pi r/t

Excellent. You could go on from there to obtain the expression for acceleration: $a = 4\ \text{pi}\ r/t^2 = v^2/r$.

(wa) Speed has dimensions of distance divided by time. What distance does the point of the radius vector travel in one period?

hint The radius vector travels a distance 2 pi r in one period, t. Please type in the correct answer: v = 2 pi rt

3. Dr. Franck used a frictionless disk attached by a string to a center post, with a rubber ring inserted to "measure" the force in the string. He started the disk in uniform circular motion about the post, and photographed the motion throughout the circle. Was the amount of stretch of the rubber ring the same at every position in the circle?

(ca) Yes

Right. Showing that the force acting through the string was constant. Since the string is always at right angles to the disk's path, a constant pull at right angles will produce a curve constantly and uniformly bent everywhere. Such a curve is a circle.

(wa) Oh yes, it was. See the photograph on page 344 of PSSC Physics, second edition. Try again.

hint This is a yes or no memory question. See the photograph on page 344 of PSSC Physics, second edition. Try again.

4. In the uniform circular motion experiment (two questions back) Franck used the same size force as Purcell did in his straight-line experiments in the inertia film. Was the magnitude of the acceleration for circular motion found to be the same as for straight-line motion?

(ca) Yes

Eureka! It was. This shows that the inertial mass of the body is the same for circular motion as for straight-line motion, and suggests that Newton's law is a vector law, with mass a scalar quantity.

(wa) You're wrong, but be happy for the physicists that the answer is yes.

hint This movie had a happy ending. Everything checked out. Try again.

OK. Now go back and hear the remainder of your lecture. Then report back here for a quiz on the material covered.

lecture quiz

Now, for a few questions on the context of this last lecture. Try to do well on them.

1. If an object is being accelerated such that only the direction of its velocity is changing, then the object is moving in a

   a. straight line
   b. circle
   c. generally curving but non-circular path.
   d. hint

(ca) b. Well done.

   a. No, if the object is moving in a straight line then the direction of its velocity is constant. Try again.

   c. No, if the object is moving in a generally curving, but non-circular path then the magnitude of the velocity is also changing. Try again.

   d. The moon is an example of a similar condition.

2. The acceleration associated with circular motion at constant speed is given a special name. It's called the ____________ acceleration.

(ca) centripetal. Right.

(cb) centripital. Right, but you've misspelled it. It's centripetal.

(wa) centrifugal. Wrong. The answer is centripetal. These two terms are frequently confused, but "centrifugal" force is what is called a fictitious force.

(un) The answer is centripetal. Enter that now.

hint The name means "center-seeking."

3. There are several important concepts within the topic of circular motion which you will be called upon to understand as we move further along in this course. The most important of these involves the effect of acceleration in circular motion which tells us that there is a force present. The effect is:

   a. a change in magnitude and direction of the velocity vector.
   b. change in the direction of the motion.

c. predicted by a changing rate of rotation.
d. hint

(ca) b. That's right.

a. No. In circular motion, the direction but not the magnitude of the velocity is changed. A change in either direction or magnitude or both is an acceleration. Try again.

c. No, even at constant rate of rotation, there is an acceleration in circular motion. What does it do?

d. If we know that an object swung about your head on a string will fly away in a straight line if the string is cut, its motion is being caused to change by something from the straight-line-path it wants to fly. That something is centripetal force.

4. An object is moving in a circular orbit at constant speed according to the rules of circular motion. It is kept moving by:

a. the deflecting force
b. inertia
c. some other source
d. hint

(ca) b. Yes. This is a tricky point, and very important to see.

a. No. Remember that a deflecting force is responsible for a change in direction only.

d. A deflecting force produces a change in direction only.

c. No. Some sort of energy was required to get it moving originally. However, once it has gotten started, inertia is what keeps it in motion, while the deflecting force is what keeps its direction changing.

5. Imagine for a moment that you are an electron traveling at high speed and just entering a magnetic field. If a moving electron is accelerated at right angles to its direction of motion in a magnetic field, in what kind of path will you be traveling while going through the magnetic field?

a. a straight line in your original direction of motion.
b. a straight line at right angles to your original direction.
c. a curving path.
d. hint.

(ca) c. Good. You seem to understand that acceleration at right angles to the direction of motion produces a circular path. This is the same principle that causes the moon to orbit the earth.

b. No. Remember that accelerating a moving object at right angles to the direction of motion causes a change of direction. Now answer correctly.

a. No. The electron cannot move in a straight line as long as it remains in the field because it continues to be accelerated at right angles to its instantaneous direction of motion, not at right angles to its original direction of motion. Try again.

d. The force of the electron is always perpendicular to the instantaneous direction of motion.

You have now completed your lecture quiz for today. Tomorrow's assignment is to read sections 2.9 and 2.10 in your text. Please sign off.

Lesson 14

Textbook Quiz

1. Who first formulated the law of gravitational attraction? (last name only) ________________

(ca) newton

Right.

(un) Sir Isaac Newton did it.

Please type in your answer.

Proctor call.

2. The law Newton formulated for the force between two objects of masses M and m separated by a distance r was F = :

a. GMm/r b. GMm/r^2 c. GMm/r^3 d. Mm/r

(ca) b. Right you are.

a,c,d. No. It is important to remember that this is an inverse-square law. The correct answer is $GMMm/r^2$.

3. An earth satellite spirals in toward the earth with a continually decreasing orbital radius until it crashes into the earth. As the radius decreases, its speed:

a. increases
b. decreases
c. stays the same.

(ca) a. Right.

b,c. Wrong. Remember that $Gm/r = v^2$. Therefore, its speed increases.

4. Cavendish's device measured:

   a. depth of rainfall.
   b. the mass of the planet Jupiter.
   c. the force between masses.
   d. the depth of the English Channel.

(ca) c. Right. Too easy, though.

a,b, d. No! If you couldn't answer this, maybe you should read the chapter.

5. The constant G mentioned in this chapter is:

   a. a proportionality constant.
   b. the acceleration due to gravity at the earth's surface.
   c. an important physical constant, chosen to commemorate Galileo's work.

b , c. Wrong. The answer is a proportionality constant.

(ca) a. Correct. The Cavendish experiment determined its value.

<u>Good</u>

Excellent. Now go and listen to lecture 14 for a discussion of satellites and planets.

ready to continue.

<u>Warn</u>

If you think you're ready to go on, listen now to lecture 14 on satellites and planets. Otherwise, review the material and then repeat this quiz.

retake reading quiz   lecture quiz

<u>Stop</u>

Stop! Sign off and reread the material; then come back when you're really prepared.

Here are a few questions on the subject of planets and satellites.

<u>Lecture Quiz</u>

1. The planets move about the sun in orbits of very small eccentricity. This means that the orbits are shaped:

   a. irregularly   c. nearly circular
   b. like a football   d. hint.

(ca) c. Excellent. It is this fact which makes it relatively easy for us to describe them.

a. No. If they were irregularly shaped, we wouldn't be able to describe them in a course on this level. Try again.

Lecture Quiz

1. The planets move about the sun in orbits of a very small eccentricity. This means that the orbits are shaped:

   a. irregularly   b. like a football
   c. nearly circular   d. hint

(ca) c. Excellent. It is this fact which makes it relatively easy for us to describe them.

   a. No. If they were irregularly shaped, we wouldn't be able to describe them in a course on this level. Try again.

   b. Really? Think carefully, and try again. A circle has zero eccentricity.

2. The law of forces between two bodies, first postulated by Newton, was later verified experimentally by:

   a. Newton   b. Thomson   c. Cavendish   d. hint

(ca) c. Right. It was Cavendish who devised a method of actually testing it in the laboratory (remember that film you saw some time back?).

   a. No. Newton did not verify it experimentally. He formulated a mathematical description of what he considered the force between two bodies to be.

   b. No, Thomson is famous for other experiments. Try again.

   d. Recall a film on forces you saw earlier.

3. The kind of rocket generally used to launch a man-made satellite is called a ________________ rocket.

   a. multi-stage   c. capsule

   b. Apollo   d. solid-fueld   e. hint

(ca) a. Good.

   b. No, this is just one particular type of rocket. Try again.

   c. No, you've got your signals crossed! A capsule is not a rocket. Try again.

   d. Not necessarily. Both solid and liquid fuels are used.

   e. Take another try. This was mentioned right at the start.

4. An object is moving in a circular orbit at constant speed according to the rules of circular motion. It is kept moving by:

   a. the deflecting force.
   b. the energy which was put into the system originally to get it started.
   c. some other source.
   d. hint

(ca) b. Wonderful! This is an important point.

a. No; remember a deflecting force produces a change in direction of motion only.

c. That's news to us. What other source did you have in mind? Try again.

d. Remember that a deflecting force creates a change in direction of motion only.

5. If v is the velocity, R the radius of orbit, and T the period, then an expression for centripetal force is:

   a. $F = mv^2/R$ c. $F = 4\ pi^2\ R/T^2$

   b. $F = v^2/R$ d. hint

(ca) a. Very good.

b. Wrong! That's the centripetal acceleration. Try again.

c. No, this is just another way of writing the centripetal acceleration. Try again.

d. A force equals a mass times an acceleration.

6. An earth satellite spirals in toward the earth with a continually decreasing orbital radius until it crashes into the earth. As the radius decreases, its speed:

   a. increases c. stays the same
   b. decreases d. hint

(ca) a. Right.

b, c. Wrong. Remember that $Gm/r = v^2$. Therefore, its speed increases.

d. Remember, $v^2 = Gm/r$.

This concludes the lesson 14 lecture quiz. Now go view film 307, "Frames of Reference." When you have finished with that, come back here and we'll see how much you got out of it.

ready to continue

Here are a few questions on topics pertaining to the film "Frames of Reference." Some of them are a bit tricky--so watch out!

Film Quiz

1. While a bus is in motion along a level, straight section of road, a marble rolls across the floor from one side to the other. It is not jsubject to any force from the bus, and its path is a straight line relative to the bus. Therefore:

    a. bus' velocity is constant.
    b. bus is speeding up or slowing down.
    c. nothing can be said about bus' motion.
    d. hint.

(ca) a. Very good.

b. No. If the bus were accelerating, the marble's path would curve.

c. No, the path tells something about the frame of reference (bus).

d. If the bus is accelerating, the marble will have an apparent acceleration (relative to the bus) opposite to the bus' acceleration.

2. Later on the same bus, we roll a marble from one side to the other. This time the path is a parabola which bends toward the front of the bus. The bus is:

    a. moving forward at constant speed.
    b. accelerating forward.
    c. moving backwards at constant speed.
    d. accelerating backwards.
    e. hint

(ca) d. Excellent.

a,c. No, this would give a straight line path.

b. No, the path would be toward the back of the bus in this case. Try again.

3. A man sits on a railroad flatcar which is moving with a horizontal speed of 4 m/sec. He throws a ball vertically up with a speed of 24 m/sec. When the ball comes back down, it:

    a. lands 8 meters behind him.
    b. lands 8 meters in front of him.
    c. hits him on the head.
    d. hint

(ca) c. Right. He should have taken Ps. 107.

a,b. Unfortunately, no. Relative to the man, the ball has only a vertical component of velocity. What happened?

d. To an observer on the ground, ball and man have the same horizontal speed.

4. An example of a "fictitious" force (that is, one which we introduce to correct for the acceleration of our frame of reference) is:

   a. centripetal force
   b. centrifugal force
   c. a reactive force, such as the force a wall exerts back on you when you push on it.
   d. hint

(ca) b. Right you are. Centrifugal force is a term widely used and poorly understood.

c. No, this is a real force; it does not depend upon the wall accelerating or rotating. Try again.

a. Wrong, this is a real force. Remember how in the movie, this force exerted on a rubberband in a rotating frame of reference produced stretching that was observable in a non-rotating frame.

d. This "force" often gets blamed when a car's inertia makes it hard to follow a curve in the road.

d 5. "A frame of reference attached to the earth is an inertial frame of reference." This statement is:

   a. true
   b. true to a first approximation
   c. not true
   d. hint

(ca) b. Glad you caught that point. It is not strictly inertial because of the earth's rotation about its axis and revolution about the sun, but the accelerations involved are small compared to g, so we can normally neglect them.

a, c. You're partly right, but not entirely.

d. The earth displays rotational motion.

This concludes your quiz on the film, "Frames of Reference." Next time, we'll take up the subject of impulsive force and momentum. Please read section 2.8 in your text for then. Sign off now.

Lesson 15

Textbook Quiz

1. An impulsive force is always associated with a:

   a. change in mass
   b. change in direction
   c. change in momentum

(ca) c. Right you are!

a. No, not always. But a change in momentum is always present.

b. No, a change in direction might occur, but it is not necessary. A change in momentum is always associated with an impulsive force.

2. The principle of conservation of linear momentum is clearly observed in a:

   a. galloping horse
   b. skier going down a steep slope
   c. rocket

(ca) c. Good.

a,b. No. You evidently didn't read your assignment very carefully. Let's try another one.

3. A force multiplied by the time during which it acts is called:

   a. momentum   c. power
   b. impulse   d. impact

(ca) d. Excellent.

a,b,c. No, if you check back, you'll find that the answer is impulse.

4. Two ice skaters, facing each other, push off. If the heavier skater moves off at 3 m/sec, the skater of less mass moves off with a speed:

   a. equal to 3 m/sec   c. less than 3 m/sec.
   b. greater than 3 m/sec

(ca) b. Right, since the product mv must be the same for each.

a. No, the total momentum must be zero and therefore the product mv must be the same for both skaters.

c. No, the lighter mass must have a greater speed in order to have the same momentum as the heavier one.

Warn

You can retake this quiz after looking over the reading material again, or you can proceed directly to lecture 15 on momentum. The choice is up to you.

retake reading quiz   lecture quiz

Stop

You'll have to retake this quiz before you can go on, since you didn't do very well. Sign off now and reread today's assignment.

Good

You've passed the reading quiz; now go listen to lecture 15 on "Impulse and Momentum." Indicate when ready to continue.

Now for a few questions on the lecture you just listened to.

Lecture Quiz

1. An elastic collision is one in which:

   a. the colliding objects are not bent, broken, or deformed in any way.

   b. the colliding objects are not permanently bent, broken, or deformed in any way.

   c. kinetic energy is not conserved.

   d. hint

(ca) b. Excellent.

a. No, colliding objects are always temporarily deformed, even if the deformation is very minute. Try again.

c. No, kinetic energy is conserved in an elastic collision.

d. What does "elastic" mean?

2. Momentum is conserved:

   a. always
   b. never
   c. only when kinetic energy is conserved.

(ca) a. Right! And it's very important to realize this.

b. Tsk, tsk, you goofed pretty badly on that one. Try a, c, or d.

c, d. No. This was mentioned explicitly in your lecture. Try again.

e. Two interacting particles exert equal but opposite forces on each other, so the net impulse is zero.

3. We usually associate impulse with:

   a. a short time interval
   b. an indefinite, long time
   c. the earth's rotation
   d. an inelastic collision
   e. hint

(ca) a. Good. You seem to understand.

b. No, we never said any such thing!

c. No. Perhaps you had better go back and review the subject of impulse.

d. No; it is associated with collisions, but not necessarily inelastic ones.

e. The force with which a bat strikes a baseball is an impulsive force.

4. Body A, with a mass of 7 kg. and a velocity of 9 m/sec north, collides with body B, which has a velocity of 10 m/sec north, and a mass of 15 kg. What is the total momentum of the system?

   a. 63 kg m/sec north
   b. 213 kg m/sec north
   c. 150 kg m/sec north
   d. hint

(ca) b. Very good.

a, c. No, this is the momentum of one of the bodies, but the total momentum is the sum of the momenta of both bodies. Try again.

d. The total momentum is the vector sum of the momenta of both bodies.

5. A ball of mass 1 kg, traveling at 3 m/sec, collides head-on with a ball of mass 2 kg at rest. After the collision, the 1 kg ball moves away with a speed of 1 m/sec in its original direction of motion. The 2 kg ball is also now moving. What is its speed?

   a. .5 m/sec b. 2 m/sec c. 1 m/sec d. hint

(ca) c. Right. This is a very important type of problem.

a,b. No, remember your formula:

$$m_1v_1 + m_2v_2 = m_1'v_1' + m_2'v_2'.$$ Try again.

d. Recall: $m_1v_1 + m_2v_2 = m_1'v_1' + m_2'v_2'$

You have now completed lesson 15. For next time, read section 2.7 in Van Name. Sign off now.

Lesson 16

Textbook Quiz

1. The product of a force and the parallel distance through which it acts is called:

   a. momentum   b. power   c. work

(ca) c. Good.

   a. No. You should know from the last lesson that momentum is the product of mass times velocity. The answer is work.

   b. Sorry, you must not have read the text carefully. The correct answer is work. Let's try another question.

2. When work is done on an object, the object's energy changes (type true or false).

(ca) True.

   Very good. I'm proud of you.

(wa) No, that statement is true.

3. Power is measured in units of:

   a. (force) x (distance)
   b. work/time
   c. (weight) x (height)

(ca) b. Very good.

   a. Sorry; (force) x (distance) is work. The correct answer is work/time.

   c. No; (weight) x (height) is the same as (force) x (distance) which is work! The correct answer is work/time.

4. The unit of power is the:

   a. watt   b. joule   c. newton-meter

(ca) a. Fine!

   b,c. No, this is a unit of energy. The answer is watt.

Warn

You could do with some review, but if you want to go ahead, it's up to you. Either retake this quiz when you know the material better, or proceed directly to lecture 16, "Energy and Work."

retake reading quiz   lecture quiz

Good

You have successfully completed today's reading quiz. Now go and hear lecture 16, the subject of which is energy and work.

ready to continue

Stop

You'll have to go back and reread the assignment and then take this test over before you can go on. Sign off now.

1. Energy of motion:

   a. potential   c. momentum
   b. kinetic   d. hint

(ca) b. Fine.

   a. No. That's next lesson! Try again.

   c. No, momentum is not energy. Momentum is momentum. Try again.

   d. One of these isn't energy at all, so that narrows it down to two choices.

(un) Please make a choice.

2. If a ball of mass 1 Kg and velocity 1 m/sec collides head-on and elastically with another ball of mass 1 kg which is at rest:

   a. The two balls will both move off in opposite directions at the speed of .5 m/sec.

   b. The two balls will both move off in the same direction at the speed of .5 m/sec.

   c. The first ball will come to rest and the second will move off with a speed of 1 m/sec.

   d. Hint.

(ca) c. Good work.

   a. No, total momentum is not zero.

   d. Kinetic energy must be conserved.

   b. No, kinetic energy must be conserved.

3. If you push with all your might against an immovable brick wall the amount of work you have done is:

   a. none   b. too much   c. can't tell   d. hint

(ca) a. Good for you. The wall doesn't move, so no work is done.

b. Sorry. You may feel that way, but that's not the correct answer.

c. Wrong: you can tell. Now answer correctly.

d. Remember W = Fd.

4. Two balls A and B of equal mass collide elastically. Before collision, A had a kinetic energy of 57 joules and B had a kinetic energy of 50 joules. After the collision:

   a. the total kinetic energy of A and B is 107 joules.
   b. the total kinetic energy of A and B is 7 joules.
   c. Nothing can be said about the total kinetic energy.
   d. hint.

(ca) a. Correct.

b. No, total kinetic energy is conserved in elastic collisions and would be the sum of the kinetic energies of A and B.

c. Wrong. Remember that total kinetic energy is conserved in elastic collisions. Now try again.

d. Conservation of energy!!!

5. How much work would be required to lift a 50 Kg box to a height of 5 meters?

   a. 10 joules
   b. 250 joules
   c. 2450 joules
   d. hint

(ca) c. Very good.

a,b. Remember that work equals the component of force in the direction of motion times the distance moved. In this case, the force is equal to the weight (W = mg) and points in the direction of motion (up), so that work = mgd. Now answer correctly.

d. This is a little trickier than it looks. Remember, W = Fd.

That's all for your lecture quiz. Now go view PSSC film 311 "Energy and work." When you have finished with that, report back here for a review.

film quiz

Film Quiz

1. In the film at the end of its fall, the ball struck a spike in a piece of wood, driving the spike farther in. The ball's kinetic energy was converted into ____________________ energy. (Type hint if desired.)

(ca) thermal heat

Yes.

(wa) Internal.

Yes, but what kind of internal energy?

(wa) Frictional.

You're on the right track. Friction is a force which is generally associated with this kind of energy.

hint The thermometer reading increased. Think of the names of some of the names of some forms of energy -- kinetic? Potential? Thermal? Name the correct one.

The word is thermal. Enter that now.

2. Remember the ball that was lifted to a 3-meter height and then released? When the ball was halfway down in its fall, it had:

a. potential energy
b. kinetic energy
c. potential and kinetic energy
d. hint

(ca) c. Correct.

a,b. Well, you're partly right, but not right enough. Remember that potential energy is energy of position and kinetic energy is energy of motion. Now we've given it away, so type in the correct choice.

d. Halfway down, it was moving and it still had some distance left to fall.

3. Two forms of mechanical energy are ____________ energy and ___________ energy. (Type two words, or hint.)

(ca) Potential, kinetic

Good. Let's continue.

hint One is energy of motion; the other is energy stored in a system as a function of relative positions of bodies.

(wa) Potential? Thermal? Kinetic? Nuclear? Which two are mechanical?

(wa) The two kinds of energy are kinetic and potential. Type them in now.

(wa) Nuclear, thermal, heat

No, this is not mechanical energy. Answer correctly now.

4. A spring is stretched so that 25 joules of potential energy are stored in the spring. If this energy is released by letting the spring do work to accelerate a 4.3 Kg cart from rest, what will be the final kinetic energy of the cart (neglecting friction)?

(ca) 25 joules.

Very good.

(wa) 25; 25.0.

25 fig newtons? 25 push-ups? 25 what?

(un) The spring when released will give up all its potential energy which will be transferred to the cart's kinetic energy.

(un) The final kinetic energy of the cart will equal the potential energy given up by the spring system, or 25 joules. Type that now.

hint Remember conservation of energy!

This completes lesson 16. Next time, we will discuss a different kind of energy, potential energy. For then, reread section 2.7 in Van Name, and have it well in mind. You may sign off now.

Lesson 17

Textbook Quiz

1. Potential energy is energy which a body has by virtue of its

   a. motion   b. position

(ca) b. Correct.

a. No, that's kinetic energy. The second choice is the correct one.

2. Doing work to lift a mass at constant speed up to a height of 50 meters increases the ______________ of the mass.

   a. kinetic energy

   b. power

   c. potential energy

(ca) c. Absolutely correct.

a,b. Wrong. Lifting an object increases the object's potential energy.

3. Can potential energy be converted to kinetic energy? (answer yes or no) __________.

(ca) Yes.

Exactly.

(wa) Yes, it can. For example, allowing an object to fall changes its potential energy to kinetic energy.

4. When a child goes down a slide in a playground, he has:

   a. converted kinetic energy into potential energy.
   b. converted potential energy into kinetic energy.
   c. converted momentum into kinetic energy.

(ca) b. Of course!

a. No, the child has no kinetic energy at the top of the slide. The second choice is correct.

c. Wrong! Momentum is not converted into energy, or vice versa. The second choice is the correct one.

Good

You are ready for lecture 17, on potential energy. Please go and listen to it now.

ready to continue.

Warn

If you think you're ready for lecture 17 on potential energy, go and listen to it now. Otherwise, take this reading quiz over again before going on.

retake reading quiz   lecture quiz

Stop

You can't go on until you retake this quiz and do better. Sign off now, and come back when you're ready.

Before lecture quiz:

Here are a few questions designed to test your understanding of potential energy.

1. A 30 Kg mass is 40 m above a concrete floor. What potential energy does the object have with respect to the floor?

   a. 1200 joules   c. 1.176×10^3
   b. 11760 joules   d. 11760 newtons   e. hint

(ca) b. Excellent.

a. Wrong. Potential energy = mgh, not mh. Try again.

c. Wrong. You need to review scientific notation.

d. No, energy is not measured in newtons.

e. Be careful! Remember, $g = 9.8\ m/sec^2$.

2. A man who weighs 700 newtons climbs from sea level to the top of Mt. Blanc, a distance of about 4730 meters. By what amount has he raised his potential energy?

    a. 6.76 joules c. 3.31×10^5

    b. 3.31×10^6 d. hint

(ca) b. Excellent.

a. No, you're way off. P.E. = mgh.

c. That's the right idea, but your figuring is off by quite a bit.

d. P.E. = mgh.

3. An object with a kinetic energy of 600 joules causes a spring to be compressed by losing 350 joules of kinetic energy. Assuming no frictional losses, how much energy is stored in the spring at this moment?

    a. 600 joules c. 350 joules

    b. 250 joules d. hint

(ca) c. That's right.

a. Come on now. Remember kinetic energy lost equals potential energy gained.

b. No, that's how much kinetic energy the object had after losing enough to compress the spring.

d. Kinetic energy lost equals potential energy gained.

4. A 5 kg rock is dropped a distance of 2 meters and lands on your big toe. How much energy is given to your poor toe?

    a. 98 joules c. Too much.

    b. 4.9 joules d. hint

(ca) a. Your answer is correct. I'm sorry about your toe.

b. How did you arrive at that? Look at this:

Energy to toe = K.E. lost
K.E. gained = P.E. lost
P.E. = mgh

c. I gathered that from the scream. Try a numerical answer now.

d. In this case, energy to toe = P.E. lost.

5. Which of these represents potential energy?

   a. The energy of a speeding car.
   b. The energy stored in a battery.
   c. The energy of a rolling bowling ball.
   d. Hint.

(ca) b. Good. That's straight out of your lesson.

a, c. No, that's an example of kinetic energy.

d. Two of these examples obviously represent kinetic energy.

6. A baseball is dropped from the top of the Eiffel Tower. WHen it was at the top, it had quite a bit of potential energy. At the moment it strikes the ground, it:

   a. has lost all its energy.
   b. has more energy that it started with.
   c. has lost all its potential energy.
   d. hint.

(ca) c. Good. You understand.

a. No, think carefully. Just what <u>has</u> it lost?

b. Wrong; remember, kinetic energy gained equals potential energy lost.

d. Remember, K.E. gained = P.E. lost.

7. I am holding a pound of feathers in one hand and a pound of lead in the other (heaven knows why). Each is the same distance, d, above the ground. Which has more potential energy?

   a. feathers   b. lead   c. both the same

   d. can't tell   e. hint

(ca) c. Good, good, good!

a,b. That's wrong! Take another try.

d. Oh, yes we can too! Try again.

e. Potential energy has nothing to do with an object's texture.

That's all for lesson 17. Next time, we'll discuss a very important aspect of physics; namely, conservation of energy. Please reread section 2.7 of your text for then, and come well prepared. You may sign off now.

Lesson 18

Lecture Quiz

1. A stationary object 50 m above the earth's surface has a potential energy of 4000 joules. The object is then allowed to fall freely. 20 m from the ground, neglecting air resistance, the object's total energy is:

   a. 4000 joules c. 6000 joules

   b. 2000 joules d. zero

(ca) a. Exactly. Let's go on.

b,c,d. You missed that one. The first choice is the correct one. Let's try another.

2. A 2 kg object is allowed to fall freely from rest for 5 meters. The kinetic energy gained by the object is:

   a. 10 joules b. 25 joules c. 98 joules

(ca) c. That is correct.

a, b. Incorrect. This very problem was worked for you on page 51 of your textbook. The answer is 98 joules. Let's go on.

3. If a small falling body of mass, m, has total energy $mv^2/2 + mgh$ where v was its initial velocity and h was its initial height above the ground, then its final velocity V, just before hitting the ground is:

   a. greater than v c. the same as v since energy is conserved

   b. less than v.

(ca) a. Very good.

b. Wrong. It speeds up as it falls, so the correct choice is the first one.

c. No. <u>Total</u> energy is conserved, but a falling body gains kinetic energy as it loses potential energy. This means that its speed increases, so the first choice is correct.

4. If a spaceship is fired straight up, when its rockets cease to fire, its kinetic energy begins to:

   a. increase because of conservation of energy.
   b. decrease
   c. increase because of conservation of momentum.

(ca) b. Right! As its potential energy increases, its kinetic energy decreases.

a. Wrong. Write down the equation for conservation of energy and think about it. The middle choice is correct.

c. Wrong, the second choice is the right one.

Good

Very good. You're ready for a lecture on conservation of energy now. Go and listen to lecture 18.

ready to continue

Warn

If you think you're ready, proceed to lecture 18 on conservation of energy now. Otherwise, take this reading quiz over first.

retake quiz   film quiz

Stop

You didn't do well enough to go on. Stop here and go over the reading material until you know it well. Then take this quiz over. Sign off now.

Lecture Quiz

1. You are standing on a fire tower 50 m. above ground. What is your potential energy with regard to the ground if your mass is 80 kg.?

   a. 4×10^3 joules   c. 9.8 m/sec^2

   b. 3.92×10^4 joules   d. hint

(ca) b. Good.

   a. No. I think you have forgotten to convert mass to weight. Try again.

   c. Wrong. 9.8 m/sec^2 is the acceleration due to gravity, not energy. Answer again.

   d. Too simple! This problem doesn't really belong in this chapter at all.

2. An archer shoots an arrow with a mass of 100 g straight up with a velocity of 40 m/sec. If the archer did not move, with what energy would the arrow strike him on the head?

   a. 8×10^4 joules   c. 2×10^3 joules

   b. 80 joules   d. hint

(ca) b. Very good. You have applied the concept of conservation of energy to good effect in the solution of this problem.

a. No, you may have forgotten to put all of your units in the mks system. Check for the error and figure your answer again.

c. Wrong. Remember the relationship for determining the kinetic energy of a moving object is K.E. = $mv^2/2$. Use this to determine the arrow's kinetic energy as it leaves the bow. Then determine the energy of the arrow when it strikes the archer on the head, then reanswer.

d. The arrow has the same potential energy when it hits the archer's head as it had when first shot up.

3. An object at a great height above the ground has a potential energy of one joule. At the moment it strikes the ground, its kinetic energy is somehow measured and found to be only .9 joule. How can this be explained?

   a. Impossible.
   b. The measurement had to be incorrect.
   c. The remaining .1 joule was dissipated as heat.
   d. hint.

(ca) c. Good. You appreciate conservation of energy.

a. No, it's not impossible. Try again.

b. No, it might have been, but not necessarily. Try again.

d. There are other forms of energy besides kinetic and potential.

4. If kinetic energy is measured in joules, then potential energy is measured in ________________ (type in the name of unit).

(ca) joules (cb) newton-meter; newton-meters

Good. A joule is one Kg x m^2/sec^2.

Right, but we really wanted the name of this unit, which is the joule. The point to be stressed is that kinetic energy and potential energy are both measured in the same units.

Both kinetic energy and potential energy are energy. Therefore, they must have equivalent units. Now answer correctly by typing in the units in which potential energy is measured.

(un) Potential energy is measured in joules. Please type that in now.

hint It's named after a lesser-known scientist.

5. Two balls, A and B, of equal mass, collide elastically. Before collision, A had a kinetic energy of 75 joules and B had a kinetic energy of 50 joules. After the collision:

   a. The total kinetic energy of A and B is 125 joules.
   b. The total kinetic energy of A and B is 25 joules.
   c. Nothing can be said about the total kinetic energy.
   d. hint.

(ca) a. Correct; total kinetic energy is conserved in elastic collisions.

d. Kinetic energy is conserved in elastic collisions.

b. No, total kinetic energy is conserved in elastic collisions and would be the kinetic energy of A <u>plus</u> the kinetic energy of B. Try again.

c. Wrong. Remember that total kinetic energy is conserved in elastic collisions. Now try again.

That's all for this lecture quiz. Now ask the proctor for film 313, on conservation of energy. After you have seen it, report back here for a review.

quiz on film 313.

You have now seen that energy is conserved in the form of heat as well as in mechanical forms. This law of conservation of energy is a very useful problem solving tool. Following is a group of problems that will test your understanding of energy conservation. The first two pertain to the movie; the others to concepts covered in the lecture.

1. In which of the following examples is energy <u>not</u> converted from one form to a different form?

    a. The brake drums get hot when a car goes at constant speed down a steep hill.

    b. A car's battery is used to start the motor.

    c. Two steel balls collide in an elastic collision.

    d. hint.

(ca) c. Right, in an elastic collision, kinetic energy is conserved.

a. Wrong. Gravitational potential energy is converted to heat energy since the car does not speed up. Try again.

b. Wrong. The electrical potential energy of the battery is converted into heat energy of the spark plugs firing. Answer either a or c.

d. One of these situations represents only one kind of energy.

You have now completed lesson 18. Next time we will begin the study of electricity. Your assignment is to read section 4.1 in your text. Now, sign off.

Lesson 19

Textbook Quiz

1. The magnitude of the electric field at a point 1 cm. from a charge Q is measured and found to be 8.0×10^4 nt/coulomb. What would the field magnitude be at a point 2 cm. from Q?

   a. 2.0×10^4 nt/coulomb

   b. 4.0×10^4 nt/coulomb

   c. 8.0×10^4 nt/coulomb

(ca) a. Right.

b. No, the field is proportional to the inverse square of the distance from Q. Therefore, the first choice is correct.

c. No, the first choice is correct. Better review; this is important.

2. The French physicist Coulomb discovered that the force between two small charges Q(1) and Q(2), separated by a distance, d, is proportional to the:

   a. sum of Q(1) and Q(2)

   b. difference between Q(1) and Q(2)

   c. product of Q(1) and Q(2)

(ca) c. Correct.

a,b. No, you'd better reread that part. The third choice is the right one.

3. If a constant current of 1 ampere flows in a conductor, the amount of charge which passes a given point in 6 seconds is ________ coulombs (type a numeral only).

(ca) Six

Very good.

(un) Your answer should have been 6 (six). Let's go on.

4. The potential difference between two points a and b can be expressed in units of:

   a. joules per coulomb
   b. volts
   c. either of these

(ca) c. Excellent.

a,b. This is a correct unit, but so is the other one. You should have answered "either of these."

Good

You've done very well so you're ready to go on. Listen to lecture 19, "Introduction to Electrical Forces," now.

ready to continue

Warn

If you think you're ready to go on, get lecture 19 on "Introduction to Electrical Forces" now; otherwise, review the assignment and then take this quiz over.

retake reading quiz lecture quiz

Stop

You did too poorly. Sign off and reread today's assignment. Then take this test over.

Now, for some questions on today's lecture.

Lecture Quiz

1. Electrical charge comes in tiny fundamental units which are:

   a. always in motion b. of differing magnitudes

   c. all of the same magnitude d. hint

(ca) c. Very good.

   a. No, we never said that.

   b. That's not what we said.

   d. The word "fundamental" is a clue. Please make a choice.

2. Which one of the following is true?

   a. like charges attract each other and unlike charges repel each other.

   b. like charges repel each other and unlike charges attract each other

   c. A pair of positive charges will attract each other and a pair of negative charges will repel each other.

   d. Hint.

(ca) b. Very good.

a, c. No, that's not it. Try again.

Please make a choice.

d. Remember when we said that two glass rods rubbed with silk or two rubber rods rubbed with fur would repel each other? What does this suggest to you?

3. The law of electrostatic attraction was formulated by:

a. Coulomb b. Ampere c. Volta d. hint

(ca) a. Good. for you.

b, c. No, he's not the one. Try another choice.

d. A unit of electrostatic charge is named for him.

4. Coulomb's law for the electrical force between two charges is very similar to Newton's law for the gravitational force between two point masses. To see the analogy, we must realize that:

a. Charge corresponds to mass and K corresponds to G.

b. Q(2) must be negative.

c. The product Q(1)Q(2) must be negative

d. hint

(ca) a. You're right. The basic difference between the laws is that electrostatic forces may be either attractive or repulsive, while gravitational force is always attractive.

b. Wrong. Q(2) may be either positive or negative.

c. Wrong. The product is negative if the 2 charges are of opposite sign, but is positive if they are of the same sign.

d. Where do the signs come into these two equations?

Now go and look at film 403, "Coulomb's Law." When you are finished, come back here and we'll see how much you got out of it.

film quiz

Here are three questions on the movie you just watched:

1. Dr. Rogers used a calibrated spring balance to measure the force between two charged balls separated by a distance r. When the balls were 1 span apart, the force of repulsion was 23.7×10^{-4} newton. When the balls were 3 spans apart, the measured force was approximately:

a. 7.9×10^{-4} newton c. 2.6×10^{-4} newton

b. 71.1×10^{-4} newton d. hint

(ca) c. Correct. This verified Coulomb's Law, F is proportional to $Q(1)Q(2)/r^2$. Since r increased by a factor of 3, F decreases by a factor of 9.

a. No, this would be correct if the force were inversely proportional to the first power of r. Actually, it's inversely proportional to the square of r. Try again.

b. Wrong. As the balls are moved farther apart, the force between them gets smaller, not larger. Try again.

d. Coulomb's law is an inverse square relationship.

2. We've demonstrated the F proportional to $1/r^2$ part of Coulomb's law. Now, let's keep r constant and remove half the charge from each sphere as Dr. Rogers did in the film. The force of repulsion is now ____________ as large as it was with the original charge.

(ca) 1/4

Very good.

(wa) Wrong. Notice each sphere had its charge cut in half. Try again.

(un) Try typing hint.

hint The force is proportional to the product of the charges, Q(1)Q(2).

(un) The correct answer is 1/4; please type that in.

3. Dr. Rogers showed that the field inside a closed (well, almost closed) metal sphere was zero. Which of the following is not necessary for a zero electric field inside the container?

a. That the material of the enclosure is a conductor.

b. That Coulomb's law is an inverse r^2 relationship.

c. That the container is a sphere.

d. Hint.

(ca) c. Correct; the effect is independent of the shape of the conducting enclosure, as demonstrated by the girl in the wire cage.

Hint The girl in the wire cage demonstrated that the field was zero in that non-spherical enclosure.

a. Wrong. It's necessary that the enclosure be a conducting surface; otherwise, the charges would not be free to move and distribute themselves around the surface.

b. No. Remember Dr. Rogers gave an argument as to why the force on a charge at the point P from two squares on opposite sides of the sphere would cancel out.

Please sign off now.

Lesson 20

Textbook Quiz

1. If we call the distance between two positive charges, d, the charges repel each other with a force proportional to

   a. d b. 1/d c. $1/d^2$

(ca) c. Yes, it's that old familiar inverse-square law. Bet you wonder if there are any other types of law in physics. (There are.)

a,b. The Coulomb force is an inverse-square law; therefore, the third answer is the right one. Let's try harder on the next question.

2. The fundamental quantity, in the system of units used in Van Name is the:

   a. ampere b. coulomb c. volt

(ca) a. Very good.

b,c. Wrong. The volt is defined in terms of the coulomb, and the coulomb in terms of the ampere. So the ampere is the fundamental quantity. Some textbooks define the ampere in terms of the coulomb, so you can see the arbitrary nature of specifying one quantity as fundamental. The only restriction on choosing the fundamental quantities is that all the other quantities must be explainable in terms of these.

3. A convenient way of describing electric fields pictorially is by means of ________ of ________ (Type two words).

(ca) lines, force

Excellent. Continue.

(un) The answer is lines of force. Be sure to look this up later on page 117. It's a useful concept. Let's proceed.

4. A certain amount of external work W must be applied to move a particle with charge Q from point a to point b. The ratio W/Q is called the ____________ ____________ (Type two complete words).

(ca) potential difference.

I'm impressed. Just one more question now.

(un) This is what is meant by potential difference between the points a and b. Reread your text to see why it is so called.

5. Potential difference is measured in units of joules/coulomb. For convenience, 1 joule/coulomb is given a name. Type that name please.

(ca) volt

Correct.

(un) The answer is volt.

Good

You have done well enough to go on to lecture 20 at once. Today's subject is electrostatics. Go and listen to this lecture now.

ready to continue

Warn

If you want to take this quiz over, indicate when you are ready. Otherwise, go listen to lecture 20 on electrostatics now.

retake reading quiz   lecture quiz

Stop

Stop!! You need a review. Sign off and come back when you're better prepared.

Now here are some questions to test how much you got out of the lecture and demonstrations.

Lecture Quiz

1. A small conducting ball is charged by contact with a charged rod. Thereafter, the ball and the rod:

   a. will attract each other

   b. will repel each other

   c. will neutralize each other

   d. hint

(ca) b. Very good. They now both have an excess of the same kind of charge, and hence will repel each other.

   a. No, think again, what kind of charge do both objects have?

   c. No, they won't either. They share the same kind of charge, so they can't neutralize each other. Try again.

   d. After charging by contact, what can you say about the kind of charge to be found on both objects?

2. When an object which has been previously charged by induction is grounded, excess charges:

   a. accumulate on a metallic sphere
   b. fly off into the air
   c. drain off into the earth
   d. hint

(ca) c. Good. You understand.

a, b. No, think back to some of the experiments you saw, and try again.

d. Remember the electroscope experiment.

3. The process whereby an object is charged by bringing it near an already charged object is called:

a. induction b. conduction c. contact d. hint

(ca) a. That's right.

b. No, that's simply the property of allowing charges to flow freely.

c. No, they are not brought into contact.

d. What does induce mean?

4. When water conducts, this indicates:

a. Nothing in particular since water always conducts.
b. That the temperature is very high.
c. That there are some dissolved substances present which are producing ions.
d. hint

(ca) c. Right, absolutely pure water does not conduct.

a. No, you've evidently missed something from the lecture. Try again.

b. No, you surely know that water conducts at room temperature, since you know better than to handle electrical appliances with wet hands.

d. Pure water consists of neutral molecules.

5. A negatively charged conducting sphere is placed 5 centimeters from an uncharged electroscope. The electroscope is then grounded and the sphere removed. After the ground is removed, the electroscope will be:

a. negatively charged c. uncharged

b. positively charged d. hint

(ca) c. Good, you noticed the ground was removed after the sphere, therefore, the electroscope was uncharged.

a, b. No, notice that the sphere is removed while the electroscope is still grounded. Try again.

d. Can you charge something that's grounded?

6. An ionized molecule is one which is:

   a. an insulator

   b. dissolved in water

   c. broken down into positive and negative parts

   d. hint

(ca) c. Excellent

a. No, remember a previous question?

b. No. An ion certainly may be dissolved in water, but this is not the criterion since there are ionized gases.

d. Remember, we said ionized gases conduct electricity.

7. Under ordinary conditions, gases are:

   a. conductors b. insulators c. ionized d. hint

(ca) b. Correct. They generally become conductors only after being ionized.

a. Heavens no! If air were a conductor, we would have electric charges coming out of the wall outlets. Try again.

c. Not correct; gases are ionized only with effort.

d. Remember what we said. about ionization and the effect it has on a gas.

8. The following is a very important question. It will be very handy to have this in mind when we study modern physics later. The atom consists of:

   a. a negatively charged nucleus surrounded by positively charged electrons.

   b. a positively charged nucleus surrounded by negatively charged electrons.

   c. hint

(ca) b. Good.

a. No, the other answer is correct.

c. We've heard a good deal more about electrons than about protons so far.

9. A substance in which charged particles can move about freely is called:

   a. a conductor b. an insulator
   c. liquid d. hint

(ca) a. Right.

b. You're about as wrong as you could possibly be, so there's no way to go but up.

d. Think: What do the words "conduction" and "insulation" mean?

c. No, that's not the name, although it's true that some charged particles can move about freely in some liquids.

10. The laws of electrostatic force and gravitational force are analogous to each other, except for the fact that:

a. they operate at different distances.
b. the gravitational force is stronger.
c. the electrostatic force may be either attractive or repulsive.
d. hint.

(ca) c. Excellent. We know that gravitational forces are always attractive.

a. No, the distance referred to may be the same for both cases.

b. No, gravitational force is not stronger.

d. What do we know about the direction of gravitational force?

That's all for lesson 20. For next time read section 6.1 of your textbook. Sign off now.

Lesson 21

Textbook Quiz

1. The beam in a cathode-ray tube consists of:

a. photons b. protons c. electrons

(ca) c. Correct.

a,b. Wrong. It's a beam of electrons.

2. The conclusion drawn from Thomson's experiments with the cathode ray tube is that all cathode ray particles:

a. are identifical, that is, have the same mass, same charge.
b. have the same ratio of charge to mass.
c. can be deflected by a magnetic field.

(ca) b. Very good.

a. No, another experiment, namely Millikan's was needed to establish this.

c. No, this was known before Thomson's experiments. The second choice is the correct one.

2. Millikan observed the forces acting on charges carried by:

a. oil droplets b. droplets c. electron beams

(ca) a. Correct. Nowadays this experiment is performed using small plastic balls, instead of oil drops, to carry the charge. They have the advantage of being uniform in size and weight.

b, c. No, Millikan observed the motions of small oil drops between two parallel plates.

Warn

You could stand a review. If you want to do this, review the reading material and then repeat this quiz. Otherwise, go and hear lecture 21 on elementary charge and electric fields now.

retake reading quiz lecture quiz

Stop

I want you to stop and review this material and then take this quiz over before going any further. You don't know the material well enough yet. Sign off now.

Good

Your performance indicates that you're ready to go on with lesson 21 on elementary charge and electric fields. Go and listen to lecture 21 now.

continue

Here are some questions on electric charges and fields. Let's see how much you remember.

1. An electric field is a:

a. group of charges c. kind of energy

b. vector quantity d. hint

(ca) b. Right. Electric field has direction and magnitude at any point in space.

a. No, an electric field is certainly associated with a group of charges, but the charges themselves are not the field.

c. No, the field stores energy, but it is not a kind of energy itself.

d. The force on Q(2) is equal to Q(2) times the field strength at Q(2).

5. The field strength 0.3 m from a 9 coulomb charge is ________ nt/coulomb. (Note: $K = 9 \times 10^9$ nt. m^2/coulomb^2)

(ca) 9 x 10"

Good.

hint Field strength is equal to K times the charge divided by the square of the distance. Now try again.

(un) $E = Kq/d^2$, substitute the numbers and solve.

(un) Follow this: $E = Kq/d^2$ nt/coulomb

$$E = 9 \times 10^9 \times (9/.09)$$

$$E = 9 \times 10^{11} \text{ nt/coulomb.}$$

Now type in the answer.

This completes your quiz on lecture 21. Now ask the proctor for film 404, "Millikan Experiment." In this film, you will see how the charge on an electron can be measured. Afterwards, report back here and we'll see how much you've retained.

quiz on film 404

Film Quiz

1. The purpose of the Millikan experiment was to:

a. show that charge comes in multiples of a natural unit.

b. measure the weight of small plastic balls.

c. see if gravitational forces could be counterbalanced by electrical forces.

d. hint

(ca) a. Right, you got the message. Don't lose sight of this goal as we go through the necessary steps in the measurement.

b. No, the weight was not measured in this film although it was involved in some of the experiments. Try again.

c. No, this was done in the film, when a single ball was held motionless, but that was not the purpose of the Millikan experiment. Try again.

e. X-rays were used to change the amount of charge carried by a plastic ball. The difference in driving force on the ball, resulting from this change, was measured by the changing velocity of the ball.

2. A plastic ball was held motionless by adjusting the electric force up, F(e), to be equal and opposite to the ball's weight W. If F(e) is switched off, the ball falls at a constant speed of 5 divisions/second. If F(e) is reversed so that its pull is downward in addition to W, the ball falls at a constant speed of 10 divisions/second because:

   a. there was no air resistance acting on the ball.
   b. the speed of the ball in air is proportional to the driving force acting on it.
   c. acceleration was proportional to the electric field.
   d. hint

(ca) b. Very good. This relationship had to be established so that changes in net driving force acting on the ball could be measured by the changes in velocity.

a. On the contrary, there was air resistance. When the ball's speed becomes large enough so that air resistance equals the net driving force acting on the ball, the ball moves with constant velocity. Try again.

c. No, because the air resistance on the ball increases with the speed of the ball. Try again.

d. When F(e) is reversed, the total driving force downward = 2W, and the speed is twice the speed when only W was acting on the ball.

3. A plastic ball falls (with no electric field) at a speed of 0.1 mm/sec. With the electric field on, the ball rises at a speed of 0.1 mm/sec. If W - weight of the ball, the electric force pulling up on the ball is __________ times as large as W.

(ca) two

Right.

(wa) No, if upward electric force equals weight, the net driving force is zero, and the ball is motionless.

(wa) No, if this were so, the net driving force up would be 1/2W, so the upward motion would be only 0.05 mm/sec.

hint What is the net driving force on the ball?

(un) Type a numeral or hint.

(un) The net driving force on the ball must be qequal to W, and directed <u>up</u>. So what is the electric force up?

(un) For a net driving force of W up, the electrical force must equal 2W. Net force = electric force minus gravitational force = 2W - W = W. Type 2.

4. In the above experiment, if the same electric field is reversed, what is the downward speed of the ball in mm/sec? (Type a number only.)

(ca) 3/10

Correct.

hint The electric force, 2W in size, is now pulling downward, in addition to the W due to weight of the ball.

(un) Type a numeral or hint.

(un) The total force down is now 2W + W = 3W, so the speed will be three times the speed under gravitational pull W along.

(un) The speed will be .3 mm/sec. Please type in .3 now.

5. You are given 5 cardboard boxes, sealed shut, with various numbers of new pencils in them. No box has more than 7 pencils. You weigh the boxes and find boxes A, B, C, D, and E weight .025,.030, .015, .010, and .020 kg, respectively, and conclude all pencils probably have an equal mass. Box A has ________ more pencils than box D.

hint The difference in weight between pairs of boxes is a multiple of .005 kg, so this must be the weight of one pencil. If this were the weight of two pencils, box B would contain more than 7 pencils.

(ca) three

Very good. Do you see any similarity between this question and the Millikan experiment? If not, think about the type of data obtained on the velocities of the ball carrying different amounts of charge in the same electric force field. The velocity (and, therefore, the driving force) always changed by small integral multiples. Thus, the amount of charge on the ball must have changed by integral multiples of a fundamental, natural unit of charge.

(un) A has 3 more pencils than D. Please type 3 in.

Sign off please.

Lesson 22

Textbook Quiz

1. Coulomb's law states that the force between two electrical charges is proportional to the:

   a. distance between them.
   b. square of the distance between them divided by the square of magnitude.
   c. product of their magnitudes divided by the square of distance between them.
   d. product of their magnitude divided by the distance between them.

(ca) c. Fine. Coulomb's law is very important. It's good that you understand it.

a,b,d. Ooops, you goofed. In order to understand the material of this lesson, you need to have Coulomb's law firmly in mind. The third choice is correct.

2. Knowing the units used in the description of electrical phenomena is important to your understanding of the material we will be covering. One of the following statements is incorrect. Which one is it?

   a. One ampere is equal to one coulomb per second and measures current.

   b. One volt is equal to one joule per coulomb and measures potential difference.

   c. One watt is equal to one joule per coulomb, and measures electrical energy.

(ca) c. Right.

a, b. No, the third choice is correct.

3. According to Ohm's law, V = IR, I is current measured in amperes and V is potential difference measured in volts. R is called the ______________.

(ca) Resistance.

Correct.

(un) Wrong. You'd better look at the bottom of page 121 in your textbook. The answer is resistance. Let's go on.

4. An electric field has dimensions of:

   a. energy
   b. energy per unit charge
   c. force
   d. force per unit charge

(ca) d. Right. That's out of section 4.1.

a,b,c. Wrong; it's force per unit charge. Better remember that.

Good

Very good. You're ready to proceed. Go and listen to lecture 22 on electric energy and currents now.

ready to continue

Warn

You could have done better, but if you want to go on, proceed directly to lecture 22, on electrical energy and currents. Otherwise, reread today's assignment and then take this test over.

retake reading quiz lecture quiz

Stop

You'll have to do better on this quiz before you can go on. Sign off now and reread the assignment. Then try again.

Lecture Quiz

1. A battery whose EMF is 120 volts is connected to a circuit whose total resistance (including the battery) is 40 ohms. The current will be:

   a. 3 amperes b. 1/3 ampere
   c. 4800 amperes d. hint

(ca) a. That's right.

b. Wrong. EMF equals current times resistance. Therefore, current equals EMF divided by resistance.

c. No, Ohm's law tells you that the current is equal to the EMF divided by the total resistance. Now try again.

d. Remember that $V = IR$.

2. A small charged sphere is in a constant electric field between two large parallel plates. If the sphere carries a charge of 6 coulombs and the potential difference between the plates is 30 volts, how much work is done in moving the sphere from one plate to the other?

   a. 5 joules b. 180 joules c. 1080 joules d. hint

(ca) b. Right.

a. No. The work done is equal to the potential energy gained, which is proportional to the amount of charge moved. Try again.

c. Wrong. Remember, the work done on the charge is proportional to the amount of charge times the potential energy difference. Try again.

d. Remember that a volt is one joule per coulomb.

3. How much power is used by an electric motor that has a potential difference across its terminals of 34 joules per coulomb and a current through it of 10 amperes? (Type a numeral and a unit.) ________.

(ca) 340 watts

Right.

(un) No; power is measured in watts, and is the product of the current and the potential difference.

(un) Follow this: $P = IV$
$= 10$ amps x 34 volts
$= 340$ watts

Now type in the correct answer.

(un) The answer is 340 volts. Enter that now.

hint Remember, $P = IV$.

4. How much energy would be made available by allowing 300 coulombs to fall through a potential difference of 1,200 volts? (Type a number and proper units.) ________

(ca) 3.6×10^5 joules.

Good.

hint Remember that a volt is one joule per coulomb.

(un) Sorry. Simplify and inspect the units for a possible solution to the problem.

(un) Wrong. Try and follow: Energy is measured in joules.
1 volt = 1 joule/coulomb; therefore, volts x coulombs = joules.
Now apply this to the original question and type in your answer.

(un) The response to your last answer told you that volts x coulombs = joules, and energy is measured in joules. Substitute the data as follows:

1200 volts x 300 coulombs = 360000 joules

Converting to proper notation:

360000 joules = 3.6×10^5 joules

Now that you know the right answer, type it in.

That's all for this quiz. Today we discussed electrical energy, and in the following film, you will get a chance to see a situation in which the potential energy of electrons in an electric field is converted into kinetic energy as the electrons are accelerated across the field. In this experiment, a known number of electrons (and we know the number from knowing the current) is accelerated across an electric field and allowed to strike a target. Owing to conservation of energy (remember when we studied that?), the target heats up. Knowing this increase in temperature, we can find out how much kinetic energy was transferred.

Now ask for PSSC film 409, and find out how this experiment is carried out. When you have finished, come back here for a brief quiz.

film quiz

Film Quiz

1. In a cathode ray tube that has a copper anode identical to that of Professor Friedman's tube in the film, and that gives the electrons 8 times more kinetic energy, the temperature rise would be ____________ that in Friedman's experiment.

a. less than b. the same as c. greater than d. hint

(ca) c. Of course.

a, b. No; how could this be, when the anode absorbs more than eight times as much energy as did Friedman's with its 11 joules? Now, answer correctly.

d. Compare the numbers of joules of energy gained by the electrons in the two tubes.

2. Dr. Friedman showed that when the electric force in the vacuum tube was doubled and the current cut in half, other factors remaining the same, the same energy was gained by the electrons. This gave validity to his assumption that the electric force on a moving charged particle is:

a. independent of its speed
b. proportional to its speed
c. proportional to square of its speed
d. hint

(ca) a. Correct.

d. Does the electron speed show up in the equation?

b, c. No. This experiment was done to show that the equation predicts correct results for both cases (different speeds).

3. In the booklet, p. 26, is the calculation of kinetic energy gained by the electrons in the vacuum tube. Calculate the kinetic energy in a similar tube with the following characteristics: Force = 2.5×10^{-14} nt/elementary charge; distance between plates = 2.0 mm; current = 5×10^{-3} ampere. The current is allowed to run for one minute. What is the kinetic energy?

a. 1.55 joules b. 94×10^3 joules c. 94 joules d. hint

d. Remember, electric field has units of force per elementary charge.

2. A common way of describing an electric field is by means of:

a. lines of force b. an energy diagram

c. a series of energy and force equations d. hint

(ca) a. Good.

b. No, it's not an energy diagram.

c. No, you're way off base.

d. In the lessons, remember a picture of a field.

3. If Coulomb's law is $F = \frac{KQ_1Q_2}{R^2}$, then the field strength E due to Q_2 is:

a. $\frac{KQ_1Q_2}{R^2}$ b. $\frac{KQ_1}{R}$ c. $\frac{KQ_2}{R^2}$ d. $\frac{KQ_1Q_2}{R}$ e. hint

(ca) c. Fine. You've correctly identified field strength as force per unit charge.

a. No, that's force.

b. No, it depends on R^2 and on Q_2.

d. No, that's the worst answer of the four.

e. Try to remember the definition of field. Then it's easy.

4. The Coulomb force between two point charges, Q(1) and Q(2), is 4.5 newtons. If $Q(2) = 0.50 \times 10^{-6}$ coulombs, and $Q(1) = 15 \times 10^{-6}$ coulombs, what is the value of the electric field at Q(2)?

a. 3.0×10^5 nt/coulomb

b. 9.0×10^6 nt/coulomb

c. 3.0×10^5 coulomb^2/meter

d. hint

(ca) b. Good for you.

a. No, this is the magnitude of the field at Q(1). Try again.

c. What on earth kind of units are those? Try again.

d. The electric charge/sec = $(5.0 \times 10^{-3})(6.25 \times 10^{18})$ el. ch/sec. = 3.125×10^{16} el. ch./sec. . Now substitute this in the equation along with the force, distance, and time (in seconds). Watch your powers-of-ten carefully.

a. No. Perhaps you forgot to change the 1 minute to 60 seconds. Try again.

b. No, did you remember to express 2 mm as 2×10^{-3} meters? Try again.

(ca) c. Very good. And since this equation, which uses both the Millikan elementary charge (in the force/elem. ch. factor), and the Faraday elementary charge (in the elem. ch/sec. factor), correctly predicts experimental results, we conclude that these two units of charge are the same.

4. Assuming this tube (in the previous question) has a copper anode identical to that in Friedman's tube in the film, the temperature rise would be __________ that in Friedman's experiment.

   a. less than   b. the same as   c. greater than   d. hint

(ca) c. Of course.

a, b. How could this be when the anode absorbs more than eight times as much as the 11 joules of Friedman's tube? Now answer correctly.

d. Compare the number of joules of energy gained by the electrons in the two tubes.

This completes lesson 22. For next time, read sections 4.1 and 4.2 in Van Name. I'll see you then. Sign off.

Lesson 23

Film Quiz

1. The force between two magnetic poles separated by a distance, d, is proportional to:

   a. d   b. 1/d   c. $1/d^2$

(ca) c. Right. Notice this is the same type of force as the gravitational force between masses and the Coulomb electrostatic force.

a. No, the force becomes smaller, not larger, for larger separation d. The third choice is correct.

b. No. You're correct in thinking that the force decreases as separation d gets larger, but it is not 1/d dependence. The third choice is the right one.

2. A magnetic field exerts a force on an electric charge moving in it. This force is at a maximum when the velocity of the charge:

   a. is parallel to the magnetic field
   b. makes a 45 degree angle with the magnetic field
   c. is perpendicular to the magnetic field

(ca) c. Right you are.

a, b. No, that's incorrect. The force is greatest when the velocity is perpendicular to the direction of the field.

3. The force F on a conductor of length L carrying a current I in a magnetic field B at right angles to the conductor is given by F = BLI. If a short in a power station causes a current of 10000 amps in a conductor 2m long, the earth's magnetic field causes a force that:

   a. is negligible compared to the force of gravity.
   b. may move the conductor, but not noticeably.
   c. may rip the conductor from its mountings.

(ca) c. Yes, F in this case would be 1 newton.

b, a. No, as shown in your text, the force is not negligible. The third choice is correct.

4. If a magnetic field exists, it must be the result of:

   a. an electromagnetic
   b. a bar magnet
   c. a moving charge

(ca) c. That's right. All magnetic effects are due to moving charges.

a,b. Wrong. It is very important that you realize that all magnetic effects are due to moving charges.

Good

Good work. You are ready to go ahead with lesson 23. Today's lecture is a demonstration lecture, and the subject is magnetism. Get started now.

continue

Warn

Since you missed more than one question, you might benefit by taking this quiz over again before going on. Do that now if you want to; otherwise proceed directly to lecture 23, on magnetism.

retake reading quiz   lecture quiz

Stop

Before you go any farther, you'll just have to stop and review. You can't hope to understand this subject without the proper preparation. Please sign off now and reread the assignment; then come back and take the quiz over when you are properly prepared.

Here are a few questions pertaining to topics covered in today's lecture and film-loop demonstrations.

1. Does it make any difference in the end result whether it is the charged object or the magnetic field which is moving? (Type yes or no.) ________

(ca) No.

Excellent. You saw that the charge is only interested in relative motion, not absolute motion.

(wa) Wrong. Can you think of any way the charge can tell whether it is moving or the magnetic field is moving? The charge is interested only in relative motion. Try again.

hint Can you think of any way the charge can tell whether it is moving or the magnetic field is moving?

2. Do the lines of force of a magnetic field form closed loops? (Yes or no) ________

(ca) Yes.

Correct.

(wa) Wrong; unlike the lines of force in an electric field, magnetic force field lines do form closed loops. Now answer correctly.

hint Magnetic poles (north and south) always come in pairs.

3. How does the strength of a magnetic field produced by a current-carrying wire depends on the magnitude of the currents? It is:

a. directly proportional to the magnitude of the current.
b. directly proportional to the square of the magnitude of the current.
c. inversely proportional to the magnitude of the current.
d. hint.

(ca) a. Correct.

b. No, but it is true that magnetic field strength B is larger for larger currents. Try again.

c. Wrong. This would mean that extremely high fields would be experienced as the current in the wire is reduced toward zero. Try again.

d. The magnetic field produced by an electric current increases in flux density linearly as the magnitude of the current.

4. An proton is a charged particle with a positive elementary charge. A proton initially moving with constant velocity enters a magnetic field which points at right angles to its direction of motion. The path followed by the proton in the field will be:

   a. a straight line in the direction of the field.
   b. undeviated by the field.
   c. circular.
   d. hint

(ca) c. Very good.

a. No, the right hand rule for the force on a charged particle moving at right angle to a magnetic field tells you that the resulting force is always at right angles to both velocity and magnetic field.

b. Wrong. Any charged particle moving at right angles to a magnetic field experiences a force which is not in the direction of motion but is, in fact, perpendicular to it. Take another try.

d. Remember any moving charge whose velocity is perpendicular to any component of a magnetic field experiences a magnetic force.

This completes the quiz on lesson 23. The next lesson will be on the subject of magnetic induction. This is a rather complicated subject and will take some work. Your assignment is sections 4.4 and 4.5; read it very carefully and have an understanding of the material for next time. Sign off now.

Lesson 24

Textbook Quiz

1. Henry and Faraday observed that a current is produced in a coil whenever the coil is subjected to:

   a. a constant magnetic field
   b. a changing magnetic field
   c. either a constant or a changing magnetic field.

(ca) b. Correct. Faraday moved a magnet near a coil; Henry changed the current in one coil and observed that a current was produced in a nearby coil.

a, c. No. Both men observed currents only while the magnetic field was changing.

2. The magnitude of an EMF (electromagnetic force) may be expressed in which of the following units:

   a. joules/coulomb   c. webers/m^2

   b. newtons

(ca) a. Right. EMF is not really a force at all.

b. The word "force" is misleading you. The first choice is correct (see page 133 of Van Name).

c. No, this is a unit of magnetic field strength. However, EMF could be expressed in terms of webers/sec. The first choice is the correct one.

3. The magnetic flux through an area a at right angles to a magnetic field b is defined by the equation: flux = ____________. (Type out the rest of the equation in terms of a and b.)

(ca) ab. Very good.

(un) The correct answer is ab.

4. The EMF induced in a loop rotating in a constant magnetic field once every t seconds is:

   a. directly proportional to t.
   b. independent of t.
   c. inversely proportional to t.

(ca) c. Correct.

a,b. Wrong. The faster the rotation, the larger the induced EMF, so the first choice is correct.

5. A current I flowing in a long, straight conductor establishes:

   a. an electric field but no magnetic field.
   b. a magnetic field whose magnitude is proportional to the current I.
   c. a magnetic field whose magnitude is independent of I.

(ca) b. Right you are.

a, c. Wrong. It establishes a magnetic field proportional to I.

6. Magnetic properties:

   a. are caused by motions of electric charges in atoms.
   b. can be explained only by existence of magnetic poles.
   c. are not related to electrodynamics.

(ca) a. Right. Magnetism is one aspect of electrodynamics.

b,c. No. Magnetism is one aspect of the behavior of moving charges and is studied under the branch of physics called electrodynamics. The first answer is the correct one.

7. The force per unit length, F, (in newtons) between two long parallel conductors separated by distance d (in meters) and carrying currents of I_1 and I_2 (amperes), is given by:

   a. $F = (2 \times 10^{-7})\ (I_1\ I_2)/d^2$

   b. $F = (2 \times 10^{-7})\ (I_1^2)/d$

   c. $F = (2 \times 10^{-7})\ (I_1\ I_2)/d$

(ca) c. Good.

b, a. No, the third choice is correct. Maybe you'd better review your assignment.

Warn

This was a long reading quiz because you will now have a long, rather difficult lecture, and it is very important to be well prepared today.

If you feel you're really ready for a lecture on electromagnetic induction, then go and listen to lecture 24. When you're through, you'd better briefly review your notes and then work through the lecture quiz. If you feel you're not ready to go on yet, take retake the reading quiz.

retake reading quiz   lecture quiz

Good

You're ready for today's demonstration lecture on magnetic induction. This is a rather complicated subject, and you'll have to pay close attention in order to understand it. Go and listen to it now.

continue

St. 2

You didn't do well enough to justify proceeding with the next lecture. Magnetic induction is a tricky subject and you don't stand a chance of understanding it unless you're properly prepared. Sign off now and come back when you think you can do better.

Before lecture quiz

Now, let's see how much you remember about magnetic induction.

Lecture Quiz

1. An EMF is induced in a wire loop of area A by decreasing a perpendicular magnetic field from a value B to zero in time t. A physics professor wants to quadruple the induced EMF. He can:

    a. double the original field strength, B, and reduce to one-half the original time.

    b. double A without changing B or t.

    c. double A and B and reduce t to 1/2 the original time.

    d. hint

(ca) a. Correct.

b. No, this would only double the induced EMF. Try again.

c. No, since the induced EMF is proportional to AB and inversely proportional to t, this would give him 8 times the original EMF. Try again.

d. Induced EMF is proportional to A and B and inversely proportional to t.

2. A loop of wire with an area of $0.5m^2$ is in a uniform magnetic field of 2×10^2 webers per square meter. What is the flux through the loop if the plane of the loop is perpendicular to the field?

    a. zero b. 400 webers c. 100 webers d. hint

(ca) c. Right.

a. Wrong; the flux could be zero only if the plane of the loop were parallel to the magnetic field. Try again.

d. Flux is equal to the product of the area of the loop and the component of the field perpendicular to the plane of the loop. Now answer correctly.

b. No, the flux is equal to the product of the area of the loop and the component of the field perpendicular to the plane of the loop. Try again.

3. A small loop of area A is in a constant magnetic field B produced between two pole pieces whose area is much larger than A. If the loop is perpendicular to B, and maintains this orientation as it moves sideways to a new position still within the constant field, the EMF induced in the loop by the motion:

   a. depends on how fast the loop is moved.
   b. is zero
   c. is a function of the constant magnitude of the field.

(ca) b. Excellent!

   a. No; since the loop stays perpendicular to a constant magnetic field, the amount of flux through the loop does not change.

   c. No; induced EMF is proportional to rate of change of flux through the loop. If B and A don't change, neither does flux.

   d. How much does the flux through the loop change? Now apply this to the problem.

4. A 0.3 meter coil of wire is concentric to a 0.5 meter coil of wire. If a current of 3 amps at 6 volts is started in a clockwise direction in the 0.3 m coil, in what direction will the induced current in the 0.5 m coil flow?

   a. clockwise
   b. counter-clockwise
   c. No current will flow because the 0.3m coil is inside the 0.5m coil.
   d. hint

(ca) b. That's right. You applied Lenz's law to the solution of this problem.

   a. I'm sorry, but that's not right. Recall Lenz's law, which tends to maintain the status quo. Please try again.

   c. No, the fact that the primary coil is inside of the secondary coil does not mean that the magnitude flux change produced will not affect the secondary. Remember Lenz's law and try again.

   d. Remember that Lenz's law means that the status quo tends to prevail.

5. A magnetic field passes through a closed loop of conducting wire. If the magnetic field suddenly begins to decrease, a current will be induced in the wire. According to Lenz's law, the magnetic field set up by this induced current will have the direction and magnitude necessary to:

   a. cause the net field through the loop to decrease twice as rapidly.
   b. keep the net field through the loop same as before the decrease started.

c. reverse the direction of the field through the loop.
d. hint.

(ca) b. Very good.

a, c. No. What does Lenz's law tell you?

d. What does Lenz's law tell you?

6. A coil consisting of 200 turns, each of area $0.1m^2$ is rotating 30 times a minute in a uniform magnetic field of 2 webers per meter^2. What is the average EMF induced in the coil as it rotates from a position parallel to the field to a position perpendicular to the field?

a. 80 volts b. 40 volts c. .1 volt d. hint

(ca) a. Good. You saw that the time it takes to make this quarter rotation is 1/4 (2sec)= 1/2 sec. (The period is 2 sec. since the rotation rate is 30 times per minute.

b, c. Wrong. See page 137 of your text (Van Name) for a similar problem. If you do not have your text with you, use the following relationship: EMF is equal to the number of coils times the change of flux through each coil per unit time.

d. Recall the relationship: EMF = change in (BA)/t, and remember that this formula is for only one turn of wire.

This completes lesson 24. Next time, we'll take up electromagnetic waves, and you'll also learn something about the mass of an electron. Read carefully section 6.1 and 5.3 and I'll see you then.

Sign off now.

Lesson 25

Textbook Quiz

1. We see lightning before we hear it because:

a. the speed of light is much greater than the speed of sound.
b. the speed of light is infinite.
c. multiple reflections result in a longer path for sound.

(ca) a. Correct.

b, c. Tsk, tsk! You should know better than that. Light travels much faster than sound. Here comes another one.

2. Which statement is true?

   a. X-rays, television and radio waves, and visible light are all electromagnetic waves.

   b. All the above except visible light are electromagnetic waves.

   c. Violet light is on the low-frequency end of the visible spectrum.

(ca) a. Right.

b, c. Sorry about that; the first choice is the right one. You should read more carefully in the future. Let's try another question.

3. Maxwell's theory predicted that in a vacuum:

   a. electromagnetic wave speed would depend on frequency.
   b. variations in electric and magnetic fields would be propagated through space with a constant speed.
   c. electric field variations travel with the speed of light, but magnetic fields travel more slowly.

(ca) b. Yes, this was a very important prediction. The constant speed is the speed of light, 3×10^8 m/sec.

a. Wrong, all frequencies travel with the same speed (the speed of light).

c. No, they both travel with the speed of light.

4. Dispersion refers to:

   a. bending of monochromatic light as it enters a liquid.
   b. scattering of light by small particles in the air.
   c. variation of index of refraction with the wavelength of the light.

(ca) c. That's very good--you seem to have read this section carefully.

a. No, dispersion cannot occur with monochromatic light because it is dependent on differences in wavelength.

b. No, that's just called scattering. The third answer is right.

Good

Very good. You're ready to proceed. Go and listen to lecture No. 25.

continue

Warn

If you think you know the material well enough to proceed with lecture 25, go ahead. Otherwise, reread the assignment and then take this test again.

retake reading quiz - lecture quiz

Stop

You missed too many questions. Go back and review the assignment and then take this quiz over. Sign off now.

Here areffour questions on the electromagnetic spectrum. See how well you can do.

Lecture Quiz

1. A "sunlamp" capable of giving you a tan is a strong emitter of:

   a. ultraviolet rays c. microwaves
   b. infrared rays d. hint

(ca) a. Right. These rays carry more energy than ordinary visible light.

b, c. Wrong. These do not carry enough energy to give you a tan. Try again.

d. Why is it dangerous to look directly at a sunlamp?

2. You have seen that for microwaves, the oscillation of electrons in the transmitting antenna causes a vibrating electromagnetic field. No, what is vibrating for light waves? ____________ ______.

(ca) Electromagnetic field.

Exactly. You seem to understand.

(un) Remember, microwaves and light waves are of the same general type; their only differences lie in their frequencies and wavelengths. Now type in the correct answer.

hint The charges in an antenna moving back and forth create a pulsating ________ ________.

(un) Type electromagnetic field.

3. Two waves, one of yellow light whose frequency is 5×10^{14}, and one a radio wave of frequency 3×10^{6} leave the same spot on earth at the same time. To an observer on the moon, it appears that:

   a. they hit the moon together
   b. the higher frequency wave hits the moon first
   c. the radio wave arrived first
   d. hint

(ca) a. Correct. In spite of differing frequencies, all electromagnetic waves propagate through space with the same velocity.

b, c. Wrong. Both of these waves are electromagnetic waves, and therefore, travel with identical velocities.

d. Both are part of the same electromagnetic spectrum.

a. Wrong. Actually, radio waves have a longer wavelength than visible light. Try again.

b. Nonsense! They have the same speed as any other type of electromagnetic radiation, including light.

d. A radio wave has a frequency of about 10^6 cycles per second.

All right. You're ready for a movie now. Go watch film 413, which deals with the mass of the electron. Then come back here for a review.

film quiz

Now for a few questions about the movie you just saw.

1. The radius r of the path of the electron beam was used to measure the amount of deflection of the beam in the cathode ray tube. If a particle's path has a larger radius R, the amount of deflection would be:

   a. larger   b. smaller   c. the same   d. hint

(ca) b. Correct. A small radius of curvature means a large deflection.

c. Definitely not. Think about this measurement which is basic to the experiment and try again.

d. The undeflected path is a straight line; the path in a magnetic field is circular. The greater the deflection, the "tighter" the circular path.

a. No, the path of a particle which experiences little deflection has a large radius of curvature. Draw two circular paths of different radii and compare the relative centripetal forces which are deflecting the particle.

2. The relationship $m = q(B^2)(r^2)/2v$ can also be expressed as $m/q = (B^2)(r^2)/2v$. If Dr. Rogers did not know the value of q, the charge on the electron, he could:

   a. still determine the mass of the electron.
   b. tell nothing about the electron's mass or charge.
   c. determine the mass-to-charge ratio of the electron.
   d. hint

(ca) c. Very good.

a. No, he measures B, r, and v, so he can compute what (m/q) must be. But if he doesn't know q, he can't get m.

b. No, he measures B, r, and v, so he can compute what the ratio (m/q) must equal. Now answer correctly.

d. He still measures B, r, and v, but doesn't know q.

3. We know $m/q = (B^2)(r^2)/2v$. Suppose we use a particle with the same charge as the electron, but whose mass is 1600 times as large. If we maintain the same v and B, instead of r = .70m, r would be:

a. .70 m/40 c. 40 x .70 m

b. 1600 x .70 m d. hint

(ca) c. Correct. For the same B and v, the radius of the path is proportional to the square root of the mass-to-charge ratio. The much larger particle would therefore be deflected by a much smaller amount; its path would have a larger r.

a. No, because m/q is larger, r must be larger. Try again.

b. No. Notice that the square of R is proportional to m/q ratio.

d. Notice that m/q is 1600 x as large. How does r depend on this ratio?

That's all for this lesson. Next time, we'll begin the study of modern physics. Be sure to read section 6.4 in your textbook for them. Sign off now.

Lesson 26

Textbook Quiz

1. The range of wavelengths for visible light is approximately:

a. 1×10^7 meters to 9×10^7 meters.

b. 4×10^{-7} meters to 7×10^{-7} meters.

c. 1×10^{-7} meters to 9×10^{-7} meters.

(ca) b. Right.

a, c. Wrong, better reread your assignment. The second choice is correct.

2. The spectrum emitted by an excited gas is:

a. Approximately the same for all elements.
b. Characteristic of a particular element.
c. A continuous spectrum with all wavelengths equally represented.

(ca) b. Absolutely correct.

a, c. Wrong. Each element has its own characteristic spectrum. Let's try another question.

3. J. J. Balmer:

   a. shot alpha particles through a collimating slit.
   b. discovered neon.
   c. noticed that the wavelengths in the visible hydrogen spectrum could be calculated from a simple formula.

(ca) c. Very good. As you will recall, the wavelengths depended upon only one variable, the quantum number n.

a, b. Not correct. This is an interesting but complicated section. Maybe you should concentrate harder when you study it. The third choice is the right one.

4. The Balmer series can be calculated from the following:

   $L = \dfrac{3.6 \times 10^{-7}}{1 - (r/n^2)}$ meters, where n represents:

   a. the number of orbital electrons in the atom.
   b. Avogadro's number
   c. integers 3, 4, 5, . . . ,

(ca) c. Fine!

a. No, that's wrong. Try again.

b. No! Before next lesson, find out what Avogadro's number <u>is</u>.

5. Spectroscopy enables physicists to:

   a. identify elements or molecules.
   b. verify the Thomson atomic model.
   c. measure the speed of light.

(ca) a. Good. That's important.

b. No! The Thomson model can't be verified because it's incorrect. The first choice is the right one.

c. No. Spectroscopy enables physicists to identify elements or molecules.

<u>Good</u>

All right, you're ready to continue with lesson 26 on the Rutherford model of the atom.

continue

Warn

You can go on to the lecture if you feel you're really ready, or you can take this quiz over first. If you don't want to retake the reading quiz, indicate continue.

retake reading quiz   continue

Stop

I'm sorry, you didn't do well enough. Please sign off and review your reading material; then come back and do better on this quiz.

In the film you are about to see, you'll be introduced to a concept which will at first seem to contradict what you have previously learned; namely, the particle nature of light. Later on we'll resolve this discrepancy by asserting that light has a dual nature, for the moment, we'll just ask you to suspend your disbelief for a while and accept the fact that light particles, called photons, do exist. In the movie, Dr. King makes an analogy between these discrete light "packets" and milk packaged in quart-sized cartons (as opposed to a quart's worth of milk flowing in a pipe). The apparatus used in his experiment is complicated; in the midst of some highly technical explanations, do not lose sight of the main point, which is as follows:

We are told that a certain amount of light can be expected to be produced every 1/2000 second. This light, however, must shine through an aperture which is only open for 1/5000 second at a time. If light represented a "continuous flow," this 1/5000 second would not be enough time for the amount of light we anticipate to get through the aperture. If, on the other hand, light is indeed "quantized," a "bundle" of light may appear at any instant during that 1/5000 second interval. This is indeed what happens; we see a distribution of flashes of light at random time intervals. This leads us to conclude that light does indeed have a particle nature.

As the proctor for film 418, "Photons," now. After you have seen it, report back here for a review.

Film Quiz

1. The purpose of the experiment in this film was to demonstrate the:

   a. wave nature of light   b. particle nature of light
   c. dual (wave-particle nature of light   d. hint

(ca) b. Correct.

a,c. No, you evidently weren't paying careful attention. Light has a dual wave-particle nature, but the experiment performed in this particular film was designed to bring out the particle aspects.

d. Did you see anything in the experiment that could not be explained by the particle theory of light?

2. The intensity of the light input to the photomultiplier is cut way down by filters:

   a. so individual photoelectrons may be detected on the oscilloscope.
   b. to avoid saturating the photomultiplier
   c. so the room temperature will remain constant
   d. hint

(ca) a. Exactly! This was essential in order to see if any individual photoelectrons were released in less than the 1/2000 second predicted by a "continuous flow" model of light energy transport.

b. No, other requirements necessitated working well below this saturation level. Try again.

c. Wrong. The filters didn't keep the heat from raising the room's temperature. Try again.

d. With no filters, the effect of the large number of photoelectrons is to form a smooth, steady pulse shape.

3. If light energy comes in "packages" instead of a continuous flow, you would expect to:

   a. have to leave the shutter open a full 1/2000 second before the pulse is seen on the oscilloscope.
   b. find that some pulses occur before the full 1/2000 second.
   c. find exactly one pulse every 1/2000 second.
   d. hint.

(ca) b, Right. This is exactly what you see in the film. Some light packages get through the shutter during the 1/5000 second it is open on each rotation, and are detected on the oscilloscope.

a, c. No. A "package" of light (or even two or three) may get through the shutter during the 1/5000 second it is open on each rotation. Try again.

d. Remember the milk cartons getting through the gate during a short open period.

Here are a few questions on the Rutherford model of the atom. See how much you can remember from the lecture.

1. Before the Rutherford experiment was performed, Sir J. J. Thomson's "plum pudding model" of the atom was generally accepted. This model described the atom as a:

   a. sphere of negative electricity in which positive particles are embedded.
   b. sphere of positive electricity in which negative electrons are embedded.
   c. a small "solar system" arrangement of protons and electrons.
   d. hint.

(ca) b. Right.

a. Not quite. This is a pudding, but which are the plums? Try again.

c. Wrong. This model came after Rutherford found evidence that most of the atom is empty space. Try again.

d. The "solar system" atom came after Rutherford's experiment.

2. In his scattering experiment, Lord Rutherford observed that:

   a. all the alpha particles were scattered within a few degrees of each other.

   b. a few alpha particles were deflected well away from the center of the atom.

   c. no alpha particles were deflected.

   d. hint.

(ca) b. Very good.

a. No, this is what Thomson predicted with his model, but Rutherford's experiment showed that this is not true.

c. No, this was true only when there was no metal foil in the path of the beam.

d. Try and remember what happened when the alpha particles hit the thin gold foil.

3. In the Rutherford model of the atom:

   a. all positive charge is concentrated in the center.
   b. all negative charge is concentrated in the center.
   c. negative charge is dispersed throughout the positive charge.
   d. hint.

(ca) a. Good for you.

b. No, better look that up again.

c. No, that's the Thomson model. Try again.

d. In Rutherford's experiment, some positive alpha particles were repelled away from the center of the target atom.

4. Which of the following is not a property of the Rutherford model of the atom?

   a. most of the mass of the atom would be concentrated in the positively-charged nucleus.
   b. the negative electrons could only have certain energies.
   c. the light electrons travelled about the nucleus in various orbits.

d. hint

(ca) b. Right, this is not a property of the Rutherford model. It is a property of Bohr's model of the atom.

a. No, this is the property of Lord Rutherford's model which explains deflection through large angles.

c. No, this is a property of Lord Rutherford's model.

d. Rutherford's model could not explain the emission of line spectra.

5. The results of Rutherford's metal foil experiment:

   a. were not in agreement with
   b. supported
   c. had nothing to do with
   d. hint

   Thomson's "plum pudding" model.

(ca) a. Good.

b,c. No, that's not right. Try again.

d. The experiment led to Rutherford's formulating his own atomic model.

All right, you're ready for our feature movie of the day now.

<u>Lesson 27</u>

Textbook Quiz

1. An electron is held in its orbit by an energy W. If a light quantum of energy E where E is greater than W impinges upon this electron, with what kinetic energy is the electron ejected from the atom?

   a. $1/2\ mv^2 = Wb$
   b. $1/2\ mv^2 = E-W$
   c. $1/2\ mv^2 = E$

(ca) b. Good.

a. Your understanding of this question is inadequate. Better look over the material again and see why $1/2\ mv^2 = E - W$.

c. Not quite. What about the energy required to remove the electron from its orbit? $1/2\ mv^2 = E - W$.

2. The photoelectric effect provides an explanation for the experimental observation that when light falls upon a metal, the electric current produced is related to the ________ of the light.

   a. frequency   b. intensity   c. velocity

(ca) a. Fine.

b. Wrong; you've evidently missed the point. It's related to frequency, not intensity.

c. No, it's related to the frequency.

3. The rate of energy emission by an ideal black body is proportional to ________ where T is the temperature in the absolute scale and K is the constant.

   a. KT   b. KT^2 c. KT^3 d. KT^4

(ca) d. Good. That's a very important result.

a,b,c. You evidently didn't read your assignment carefully enough. It's proportional to KT^4.

4. All black bodies have the same absorption and ________ characteristics.

(ca) emission; radiation

(cb) Fine. You could also have said "radiation."

(cb) Fine. You could also have said "emission;" that term is a little more commonly used.

(wa,wb) Too vague, although you're on the right track. The correct answer is "emission" or "radiation."

Good

All right; you're ready for lecture 27, on photons and the dual wave-particle nature of all matter. Go and listen to that lecture now.

lecture quiz

Warn

If you're sure you're ready to go on, get lecture 27 and listen to it now. The subject is photons and the dual wave-particle nature of matter. Otherwise, take this reading quiz over again first.

retake reading quiz   lecture quiz

Stop

You didn't do well enough to go on right away. Please sign off, review the material, and take this reading quiz over again when you think you can do better.

Display after "continue."

So! The interference pattern is characteristic of the individual protons, rather than of interference between two or more photons. What, then, is the meaning of interference? One way to think about it is that the interference pattern (a wave concept) predicts where the photon (particle concept) is most likely to be found. Now, let's go on to a few questions pertaining to the film you just saw.

film quiz

Film Quiz

1. The purpose of the experiment was to demonstrate the __________ of light.

   a. wave nature   c. dual (wave particle)
   b. particle nature   d. hint

(ca) c. Yes, we see that both concepts are needed to describe the behavior of light.

a, b. No, the interference pattern (waves) predicts where the photon (particle) is most likely to be found.

d. The interference pattern (waves) predicts where the photon (particle) is most likely to be found.

2. From the ammeter current, Dr. King estimates that about 10^7 photons per second arrive at the central maximum in the interference pattern. The speed of light is 3×10^8 m/sec, so the average distance between photons is:

   a. 30m   b. 3×10^{15} m   c. .033 m   d. hint

(ca) a. Very good. Since the box containing the apparatus is only 2 meters long, we can conclude that there is rarely more than one photon in the box at a time. Keep this in mind for the next question.

b. Wrong. You seem to have multiplied where you should have divided. Try again.

c. Wrong. If you divided 10^7 by 3×10^8, this is the number of photons per meter. You want meters per photon. Now answer correctly.

d. Meters/sec. divided by photons/sec. equals meters/photon.

3. The interference pattern examined with the photomultiplier is:

   a. due to photons interfering with other photons.
   b. characteristic of one photon itself.
   c. observable only with a weak light input.
   d. hint.

(ca) b. Right. The interference pattern (a wave concept) predicts where the photon (particle) is most likely to be found.

a. No. If there is rarely more than one photon in the box at one time, how can they interfere with each other? Besides, recall from a previous lesson that destructive interference between particles is impossible.

c. Wrong; you'd still get the pattern with stronger light. But then you'd have many photons in the box at the same time. Try again.

d. Remember that there is rarely more than one photon in the box at a time.

4. A monochromatic light beam falls on a double slit and forms an interference pattern on a screen, as in the movie. The photons arriving at the bright bands in this pattern ________________ ________ than those arriving at the darker bands.

a a. have more energy
b. are of smaller wavelength
c. are more numerous
d. hint

(ca) c. Correct.

a, b. No. For monochromatic light, the photons all have the same energy and wavelength. Now answer correctly.

d. Monochromatic light has only one wavelength and one frequency.

Here are a few questions on the lecture you just heard.

Lecture Quiz

1. A single bundle or quantum of radiation is called:

a. proton b. photon c. photoelectron d. hint

(ca) b. Good.

a. No, a proton is a positively charged particle. Try again.

c. No, photoelectrons are the electrons which comprise the current in the photoelectric effect. Try again.

d. What does the prefix "photo" mean?

2. In the experiment on the photoelectric effect, it is found that the maximum energy of a photoelectron produced from a given surface by a light source is independent of the:

a. wavelength of incident light
b. intensity of incident light
c. nature of the substance comprising the surface
d. hint

(ca) b. Well done.

a. No, the maximum energy for a given material varies linearly with the frequency, and therefore wavelength, of the incident light. Try again.

c. No, for a particular wavelength of light, the maximum energy which can be imparted to a photoelectron depends upon the substance from which the photoelectron is emitted.

d. The intensity of the incident light affects the number of photoelectrons produced.

3. Some photographic materials can be handled safely in red light but are spoiled instantly when a yellow light is turned on. How do you account for this?

   a. The frequency of the yellow light is sufficiently high to cause photoelectrons to be ejected.
   b. The yellow light is brighter.
   c. The wavelength of the red light is too small to affect the material.
   d. Hint.

(ca) a. Very good.

b. No, the brightness (number of photons striking a unit area per unit time) of the two lights may be the same, What is the physical difference between red light and yellow light? Try again.

c. On the contrary, red light has a longer wavelength than yellow light.

d. Reflect for a moment on the wavelengths involved and the relationship between energy and wavelength.

4. de Broglie hypothesized that:

   a. magnetic fields are set up by the electrons in an atom.
   b. a wavelength may be assigned to a matter particle.
   c. a photon of energy hf is emitted as an electron drops from an outer orbit to an inner one.
   d. hint

(ca) b. Very good.

a. No, that was not de Broglie's hypothesis. Try again.

c. No, this is associated with the work of Bohr. Try again.

d. de Broglie had taken note of the fact that momentum can be assigned to a photon.

5. Diffraction cannot be observed with baseballs because:

   a. only photons of light have the dual wave-particle nature.
   b. their wavelengths are too small.
   c. the quanta of energy bundles of baseballs are so large that they do not move along continuous paths.
   d. hint.

(ca) b. True, at any practical speed.

a. Wrong. The wave-particle duality is true for all matter, including light.

c. No, for microscopic objects, the energy bundles are very small.

d. At any practical speed, what wavelength would a baseball have?

6. If an electron has a momentum of 1000 kilogram-meters per second, and a proton has a momentum of 2000 kilogram-meters per second, then according to de Broglie's postulate:

   a. The wavelength of the electron is larger than that of the proton.

   b. The wavelength of the electron is smaller than that of the proton.

   c. They both have the same wavelength.

   d. hint.

(ca) a. Right.

b. Wrong. Remember, de Broglie postulated that the wavelength is inversely proportional to the momentum. Now answer correctly.

c. Wrong. Wavelength is inversely proportional to momentum; since the two particles do not have the same momentum, they cannot have the same wavelength

d. Wavelength is inversely proportional to momentum.

This concludes lesson 27. For next time, be sure to read section 6.5 of your text. You may sign off now.

Lesson 28

Textbook Quiz

1. An atomic spectrum is a series of sharp lines caused by:

   a. energy emitted as electrons change their quantum numbers
   b. heat energy emitted by the atoms as they rotate.
   c. collisions between atoms.
   d. radioactive decay.

(ca) a. Correct.

b. Wrong. There is such a thing as a rotational spectrum, but it was not discussed in this chapter. Rotational spectra are less sharp than atomic spectra. The first choice is correct.

c. No. What regularity would there be? The first choice is correct.

d. No. Radioactive decay involves a disintegration of the nucleus, and we are here concerned with the atom as a whole. The first choice is correct.

2. When Bohr's theory is applied to atoms having more than one electron, the theory does not give results which are in agreement with experiment. In order to correctly describe a multi-electron atom, another theory, known as __________ ____________ must be used.

(ca) quantum mechanics; wave mechanics.

Good. You could also have said wave mechanics.

Good. You could also have said quantum mechanics.

(un) That's not right. The correct answer is quantum mechanics or wave mechanics.

3. In the Bohr atom, the state of lowest energy (corresponding to $n = 1$) is known as the __________ state, while those states having a higher value of n are called __________ states.

(ca) ground; excited.

Excellent.

(wa,wb) No. Initial means first, and whether this is the first state in which we find the atom depends upon when we happen to observe it. The correct answer is ground state. The second part of your answer is correct.

(wa,wb) Wrong. Although you're on the right track. We do not know that these states are final for all time, since the electron may continue to change its orbit. The specific name of these states is "excited" states. The first part of your answer, however, is correct.

(un) Incorrect. You should have said ground, excited.

4. In order to cause a dominance of stimulated emission of radiation:

    a. atoms must be excited by collisions with other atoms.
    b. atoms must be excited by introducing additional electrons.
    c. the number of atoms in a higher state must be made larger than the number of those in a lower state.

(ca) c. Very good. You must have done the required reading.

a, b. No. The third choice is correct. And you should probably read section 6.5 again to find out why.

5. Bohr's theory enabled him to predict:

    a. all the frequencies of the hydrogen atom.
    b. the frequencies of all atoms.
    c. the Heisenberg theory.

(ca) a. That's right.

b. No. One needs wave mechanics to do this. The first answer is correct.

c. No! Heisenberg was responsible for that. The first choice is the correct one.

<u>Good</u>

All right; you're ready to get on with lecture 28, on the Bohr model of the atom. Ask the proctor for that tape now.

continue

<u>Warn</u>

You can either proceed directly with lecture 28 on the Bohr atomic model or you can take this reading quiz over first.

retake reading quiz   lecture quiz

<u>Stop</u>

You didn't do very well on this quiz. Please sign off now, review the assignment, and try again when you know the material better.

Here are some questions on the Bohr atomic model. See how well you can do on the following lecture quiz.

1. On the basis of Bohr's model of the atom relationships can be derived which make possible the calculation of the line spectrum of the hydrogen atom. This model makes use of the following concepts:

    a. Coulomb's law and radiation from accelerating charges.
    b. Coulomb's law and the quantization of absorption and emission of energy.
    c. gravitational attraction and the quantization of energy.
    d. hint.

(ca) b. That's right.

d. The Bohr model is associated with the existence of characteristic spectra.

a. You're half right; Coulomb's law is used. Remember, though, that radiation from accelerating charges was one of the troubles with the Rutherford model.

c. You're half right; the quantization of energy emission and absorption is an important part. But the law of gravitational attraction is not involved.

2. In the model of the atom we have just discussed, it was postulated that the electrons exist as standing waves in their orbits about the nucleus. Only certain orbits were allowed because:

   a. the standing waves will only fit into orbits with a circumference which is a whole number of times as long as the wavelength of the electron waves.

   b. protons cannot exist as waves.

   c. only certain electrons are light enough to have standing waves.

   d. hint.

(ca) a. Very good.

b. No, by de Broglie's hypothesis, all particles have wavelengths $L = h/mv$.

c. No, all electrons have the same mass.

d. In order for standing waves to exist, certain conditions must be fulfilled.

3. The first energy level above ground state for the mercury atom is 4.9 ev (electron volts). An electron whose kinetic energy is 4.2 ev collides with a mercury atom. What will be the kinetic energy of the electron after the collision?

   a. zero   b. 4.2 ev   c. 4.9 ev   d. hint

(ca) b. Excellent.

a. No, the electron's kinetic energy is not sufficient to raise a mercury atom to its first excitation state; therefore, no energy is transferred to the atom. Try again!

c. Wrong. The electron does not absorb energy from the atom. Try again.

d. No energy is transferred when supplied energy is not sufficient to raise an electron in the atom to a higher energy level.

4. Atom A emits a photon with a wavelength of 6800 Angstroms. Atom B emits a photon with a wavelength of 3400 Angstroms.

   a. Atom A loses twice as much energy as atom B.
   b. Atom B loses twice as much energy as atom A.
   c. The atoms lose equal amounts of energy.
   d. hint.

(ca) b. Right you are.

a. No; for a photon, the frequency equals the speed of light divided by the wavelength. How does energy depend upon the frequency? Try again.

d. Energy equals Planck's constant times frequency.

c. Wrong. If the photons had the same energy, they would have the same frequency and therefore the same wavelength. Try again.

<u>After Lecture Quiz</u>

All right; so much for that. Now go and view PSSC film 421, "The Franck-Hertz Experiment." When you have finished seeing it, come back here for a review.

film quiz

<u>Before Film Quiz</u>

Let's see how well you remember material that was discussed in the film "Franck-Hertz Experiment."

<u>Film Quiz</u>

1. Although Franck and Hertz were, at the time, unaware of Bohr's atomic model, their experiment later proved to be valuable verification for Bohr's model because:

   a. atoms can absorb energy in inelastic collisions with electrons.
   b. electrons could be accelerated through mercury vapor.
   c. the smallest energy that an electron can impart to a mercury atom is 4.9 volts.
   d. hint.

(ca) c. Right. And since the atom can accept only in certain amounts, we conclude that atoms can exist only in certain discrete energy states.

a. Although this is true, there is a further observation which is particularly important to the Bohr theory. Try again.

b. No, this was already known. Try again.

d. Remember the regularity of the peaks and valleys in anode current as the accelerating voltage was increased.

2. The whole tube was placed in a heating jacket for this experiment in order to:

   a. boil electrons off the cathode.
   b. vaporize the mercury.
   c. accelerate the electrons.
   d. hint.

(ca) b. Correct. Mercury vapor throughout the tube was necessary for the experiment.

a. No, there is a special heater inside the cathode to do this. Try again.

c. No, this is done by the voltage difference between the accelerating grid and the cathode. Try again.

d. At room temperature, almost all the mercury was in a "blob" in the tube.

3. Five-volt electrons pass through an unknown gas in a similar tube, and are found to retain one electron-volt of energy. From the relationship E (in electron volts) = 12400/wavelength (in Angstroms), calculate the wavelength of light that may be emitted by an excited gas.

   a. 3100 A.   b. 12400 A.   c. 2480 A.   d. hint

(ca) a. Very good.

b. Wrong. If the electrons retain 1 electron volt of energy, then the atoms absorb 4 electron volts. Try again.

c. Wrong. If the electrons retain 1 electron volt of energy, the atoms absorb only 4 electron volts. Try again.

d. The wavelength (in Angstroms) = 12400/energy (in electron volts) which the atom absorbs from the electron. Remember that the electron after collision, keeps only 1 of its original 5 electron volts.

This concludes lesson 28. Your next lesson--the final one--will be a brief summary of quantum theory and modern physics. The assignment for then is section 6.7 in your text. You may sign off now.

Lesson 29

Textbook Quiz

1. In the Compton effect, an X-ray impinges on a solid material and causes:

   a. An electron to be emitted.
   b. An eelectron to be emitted and a new X-ray of shorter wavelength to be created.
   c. Two new X-rays to be created.

   d. An electron to be emitted and a new X-ray of longer wavelength to be created.

(ca) d. Fine. You have the idea.

a. No, that's the photoelectric effect. For the more complicated Compton effect, the last choice is correct.

b. Incorrect. The new X-ray has a longer wavelength.

c. No, the fourth choice is the right one.

2. According to the Heisenberg Uncertainty Principle, the more accurately we know the position of a particle, the less accurately we know its:

   a. size   b. location   c. energy   d. momentum

(ca) d. Excellent!

c, a, b. No, that's not right. The correct answer is momentum. Perhaps you'd better reread the section if you can't remember.

3. The Uncertainty Principle predicts a similar relation to that described in the previous question between:

   a. energy and time
   b. momentum and wavelength
   c. size and shape
   d. mass and wavelength

(ca) a. Very good.

b, c, d. Wrong. The answer is energy and time.

4. If we know the position of a particle exactly, we:

   a. can determine its momentum exactly at the same time.
   b. can know nothing about its momentum at this time.
   c. know that its momentum is zero at this time.
   d. know that it will move in the next second.

(ca) b. Correct. You have an idea of what the uncertainty principle is all about.

a,c, d. Wrong. You can know nothing about its momentum at this time. That's what the Heisenberg uncertainty principle is all about.

Good

That's fine. You're ready to proceed to lecture 29 now. This is the final lecture of the course, and is concerned with a brief review of modern physics.

lecture quiz

Warn

You might do well to review the reading assignment and take this quiz over before proceeding with the next and final lecture. If you really feel you're ready to go ahead with lecture 29, though, go and listen to it now. It presents a brief summary of modern physics.

retake reading quiz   lecture quiz

Off

You missed too many questions. Please sign off for now and come back when you can do better.

Here is your last set of questions for the course. Try to finish up in a blaze of glory.

1. The atomic nucleus contains two kinds of particles. The positive ones are called ________.

(ca) proton

Very good.

No, those are the neutral particles. The positive ones are called protons.

(un) The answer is protons. Type that in now.

hint The name itself is a clue.

2. The neutral constituents of the nucleus are called ________.

(ca) neutrons.

That's right.

hint The name itself is a clue.

(un) The answer is neutrons. Please type that in now.

3. When an atom is in a "stationary state," it:

a. does not move
b. does not radiate energy
c. cannot be described by the standing wave construction.
d. hint

(ca) b. Good. You got the point.

a. Wrong. This is not what is meant by "stationary state" in this lecture.

c. Wrong. This is just when it can be described by this construction.

d. Remember what observed phenomenon Bohr's model was used to explain.

4. We can summarize some of the results of modern physics by saying that light propagates as a particle and interacts with matter as a wave.

a. true b. false c. hint

(ca) b. Good. The reverse is true: light interacts with matter as a particle and propagates as a wave.

a. No, no, no! Caught you sleeping that time! It's just the opposite: light propagates as a wave and interacts as a particle with matter.

c. Would you say that the photoelectric effect is an example of propagation or of interaction?

5. The term "atomic bomb" actually is a misnomer because:

a. molecules, rather than atoms, are involved.
b. the forces involved are not really atomic.
c. complex chemical reactions are the real source of the energy.
d. hint

(ca) b. Good for you! You've recognized that the forces involved in this type of reaction are nuclear, not atomic. Although the layman tends to confuse these two terms, to the scientist they are quite different.

a, c. No, you've missed the point. Try again.

d. "Atomic" means pertaining to the atom as a whole. Where does most of the energy in an atomic bomb come from?

This concludes your programmed P107 course. We hope you've enjoyed it as much as we've enjoyed presenting it to you.

Goodbye and good luck on your final. This exhausts our supply of platitudes.

Please sign off now.

Elementary Physics Problems for Homework and Review

INTRODUCTION

Welcome to the Computer-Assisted Instruction Center. We have developed a program to help you review some troublesome areas of your course in physics.

The organization of the material allows you to come here before each hour exam and review the main concept areas to be covered on that exam. There is also a sample exam to let you know how well you have mastered the material for the appropriate areas.

This booklet contains instructions for use of the machine and the type of notation we use in special cases. If you run into any trouble, press the button on the wall to your left to call a proctor.

INSTRUCTION FOR THE USE OF THE COMPUTER

After reading the sign on the wall to your left which explains the sign-on procedure and the technique of canceling an answer, sign on by typing all letters in lower case and without spaces:

Physics 1, your university student number

THEN: signal "EOB"

Each time you are requested to type a message on the typewriter, you must wait until the green "PROCEED" light on the right side of the keyboard is on--before typing. You must conclude your message by signaling "EOB" or else the computer will <u>not</u> react to your message.

NOTE:

1. The green "PROCEED" light on the side of the keyboard <u>must be</u> on before your typing will be accepted by the computer.
2. There is a full set of numbers available on the keyboard. That is, when typing numbers be sure you use 1 (one) and not l (el).
3. You will need a ruler to work the vectors problems.
4. When you are given a choice of answers, the correct <u>answer</u> is always present.
5. As you complete each lesson, you may take a copy of your discussion with the computer with you. (This is referred to as the "typeout".)
6. If you find that you are having difficulty, we want you to call the proctor. This may be accomplished by pressing the proctor buzzer to your immediate left.

INSTRUCTIONS FOR GETTING A HINT

For any problem in the review sections which does not have a choice similar to "I don't know" or "I need help", type "hint" in lower case letters and you will receive a short statement giving you a hint or an aid to begin the problem. Use this <u>only</u> if you can't possibly answer the question. Since you are here to help yourself to know what you don't know, we suggest that you <u>always</u> attempt to answer the question at least once before you request a hint. After all, your work down here contributes <u>only</u> what you <u>learn</u> to your course grade. And you can <u>learn</u> more by finding out whether you can answer the question correctly the first time--you certainly won't learn much by requesting hints all of the time.

There will be no hints for the sample exam questions.

INSTRUCTIONS FOR USING THE DIFFERENT PHYSICS REVIEW SECTIONS

As you finish each review section, you may select another section of problems to review by typing the appropriate message. A list of sections and messages follows:

<u>TO REVIEW</u>	<u>TYPE</u>
Orders of magnitude and scientific notation -----	go to notation
Order of magnitude only ------------------------	go to order
Scientific notation only -----------------------	to to snprob
Vectors and their use --------------------------	go to vectors
Mathematical functions and scaling theory -------	go to scaling
Mathematical functions only --------------------	go to function
Scaling theory only ----------------------------	go to scale
All films shown for exam 1 ---------------------	go to films1
The film MEASURING SMALL DISTANCES -------------	go to film104
The film CHANGE OF SCALE -----------------------	go to film106
The film CRYSTALS ------------------------------	go to film113
Algebra --	go to algebra

Be sure to type the label exactly as shown or the machine will not respond.

When you are ready to begin, pick a section and type the go to code.

GOOD LUCK!!!

EXAM INSTRUCTIONS

The sample exam will give you an indication of how well you know the material to be given on your class exam. You will not be graded on this sample exam.

As you take the sample exam you will be told whether or not your answers were correct. There are no multiple choice questions on the sample exam so you will be required to type your answers in. If units are required in the answer and you do not include them, the answer will be wrong.

Look at the sign-on notice on the wall to your left and review the procedure for canceling an incorrect answer. If you wish to cancel an answer, you must cancel before you signal EOB for that particular answer.

The machine will tell you how many problems you missed when you finish the exam.

GOOD LUCK, signal EOB when you are ready to start.

SCIENTIFIC NOTATION AND ORDER OF MAGNITUDE

You will recall from your reading that scientific notation is a shorthand method of writing numbers. It makes the handling of large and small numbers easy.

We will start by giving some examples of expressing ordinary numbers in scientific notation:

$$0.00173 = 1.73 \times 10^{-3}$$

$$15{,}000{,}000 = 1.5 \times 10^{7}$$

$$\frac{1.5}{10{,}000{,}000} = 1.5 \times 10^{-7}$$

Note that a number in scientific notation is made up of two parts. The first part, which is properly expressed as being between unity and ten, is called the coefficient. The second number, expressed as ten raised to some power, is called the power-of-ten.

You will find that in some cases of adding and subtracting numbers in scientific notation, you may have to change the coefficient so that it is not expressed between unity and ten in order to have all numbers expressed in terms of the same power-of-ten.

When you obtain an answer from any operation using scientific notation, be sure that it is expressed in proper scientific notation. (The coefficient is expressed as being between unity and ten.)

EXAMPLE:

If your answer is 32.6×10^{-3}, convert it to 3.26×10^{-2}.

While working with these problems, we will be using a typewriter that cannot type the notation as we've used it above or as you see it in your textbook.

However, the typing method we will use is not difficult to recognize and understand.

Instead of using

10^{-3}

for numbers less than one, we will type

10**-3

where the double asterisk (**) separates the exponent from the ten.

Similarly, we will use

10**5

instead of

10^{5}

when we are discussing numbers greater than one.

THE ORDER OF MAGNITUDE

The order of magnitude of a number is the <u>nearest</u> power-of-ten to that number.

Some examples follow:

NUMBER	ORDER OF MAGNITUDE
3 X 10**3	10**3
4.312 X 10**-15	10**-15
9.01 X 10**1	10**2
5.0 X 10**3	10**4
4.99 X 10**3	10**3
5.75 X 10**-3	10**-2

You will notice that the <u>nearest</u> power-of-ten is used. If the coefficient is 5 or greater, the next highest power-of-ten is used.

SQUARE ROOT

Since we cannot type the regular symbol for taking the square root, we will indicate this operation by either:

SQRT ( )   or   (   )**1/2

TYPING PRACTICE

a. $0.0017 = 1.7 \times 10^{-3}$ b. $16{,}020 = 1.602 \times 10^{4}$

FUNCTIONS AND SCALING

In this section we will review functional relationships and some of the special functional relationships found in the process of scaling.

Scaling problems concern themselves with the task of discussing models of things which are either too large or too small to be studied.

Good examples of a scale problem are the models engineers make for testing airplanes and ships before the actual vehicles are made. The tests that are performed on the models usually indicate what difficulties and errors may lie in the design. Needless to say, the expenses incurred building and revising models are substantially less than building and revising the real thing.

Your textbook discusses relationships between scale models and actual devices, the problems in this section will help you review and understand these relationships.

GASES, MOLECULES, AND ATOMS

This seven problem review section deals with the behavior of gases under certain conditions, as well as some general concepts of atoms and molecules.

Signal EOB to begin.

FILMS

This review section is designed to re-acquaint you with the films which have been shown in class thus far.

The first film, MEASURING SMALL DISTANCES, was concerned with extending our senses toward objects of very small magnitude. There were four types of instruments discussed in the film:

A. Light microscope
B. Electron microscope
C. Field emission electron microscope
D. Field emission ion microscope

their uses and qualities were pointed out.

The second film, CHANGE OF SCALE, delt with the subject of models, their usefullness and their relationship to the actual object. You saw that the characteristics of models are not the same as the real object. The review section on CHANGE OF SCALE will help you remember the relationships between models and real objects.

The third film, CRYSTALS, had two main points stressed. Try to remember what these points were before beginning the review.

ALGEBRA

This selection of problems was specifically designed to help you overcome any difficulties you may be having due to algebraic concepts and procedures.

The problems in this section make use of the following notation conventions:

1. 10^{-2} is represented by 10**-2

2. $\sqrt{2}$ is represented by sqrt(2)

Enter EOB to begin.

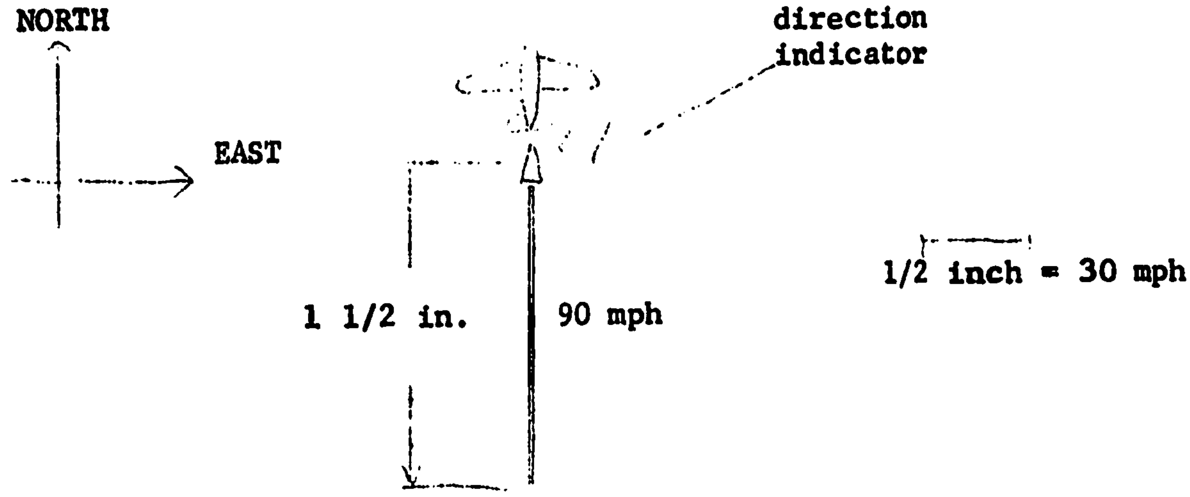
VECTORS

A vector is any quantity that has both magnitude and direction.

Vector quantities are usually represented by line segments with an arrow head on one end. The length of this line segment is proportional to the "magnitude" of the vector and the arrow head designates the "direction" of the vector.

Some examples of vector quantities are listed below:

1. Velocity vector - an airplane flying at a speed of ninety miles per hour in a northerly direction may have its motion completely described by a velocity vector having a length proportional to ninety miles per hour and pointed in a northerly direction. See Figure 1 below:



NOTE:

We have specified the reference directions in the corner of our diagram. This is desirable and necessary to avoid confusion and mis-interpretation.

Figure 1: A Velocity Vector

Force vector - the force required to lift a ten pound box from the floor may be represented by a force vector having a length proportional to ten pounds and pointed up from the floor. See Figure 2.

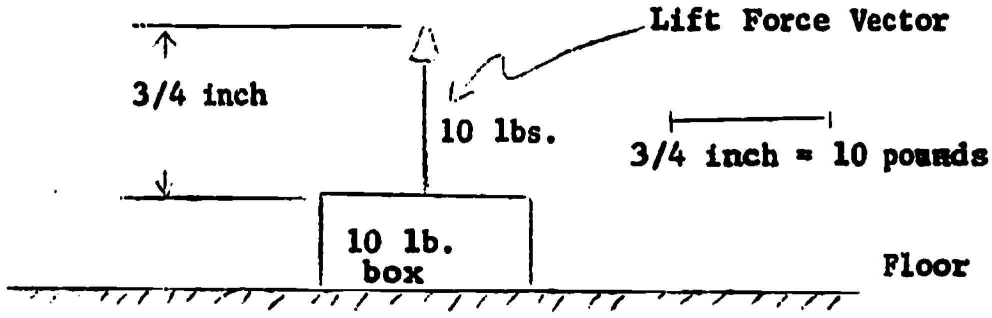


Figure 2: A Force Vector

The problems you will now see require that you construct some vectors. For this reason, we asked you to bring a ruler. If you do not have one, call for the proctor and he will loan you one of ours.

In addition to this booklet, we have also given you some graph paper. You will find this paper very useful in constructing your vectors.

To be sure we work in the same directions, always consider (see Figure 3):

1. The top of the graph paper, NORTH

2. The right-hand edge, EAST

3. The left-hand edge, WEST

4. And, the bottom edge of the paper, SOUTH.

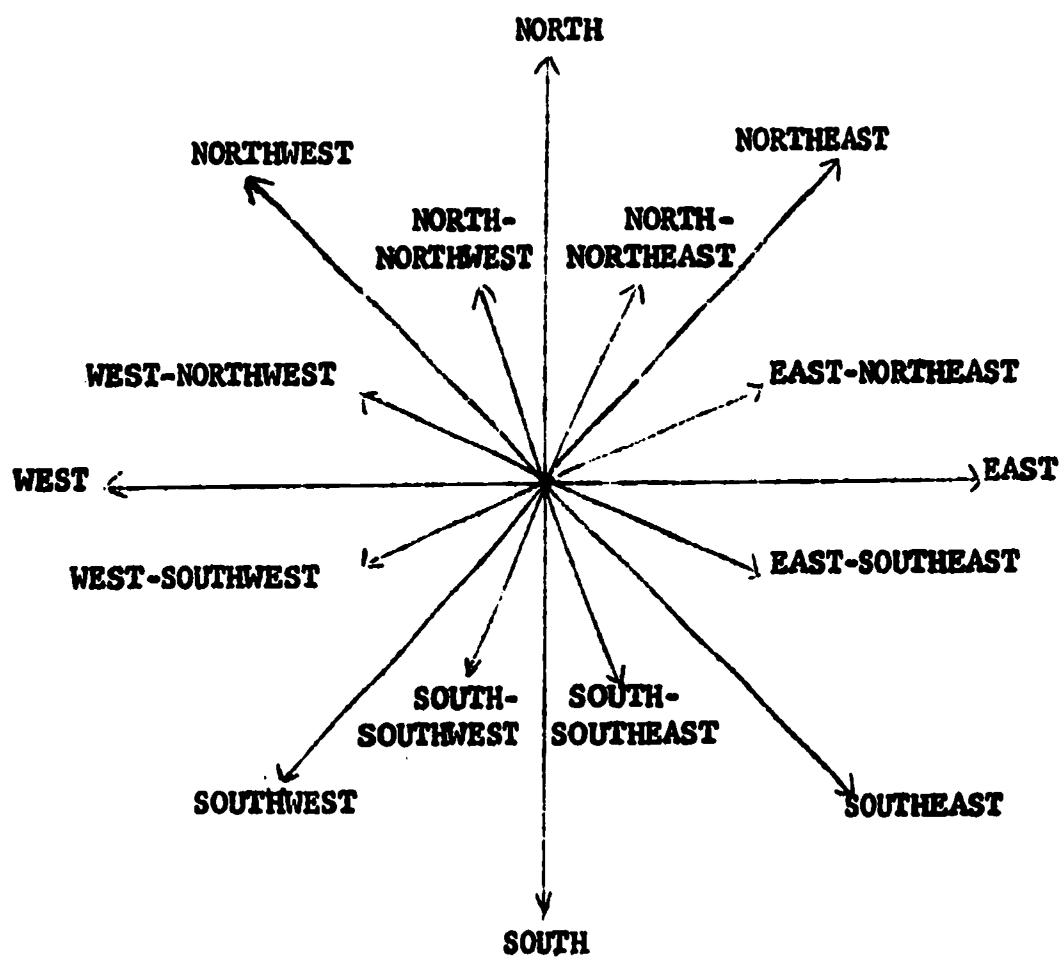


Figure 3: Directions of the Compass

When you are ready to begin,
press the EOB key.

There are four fundamental dimensions to each physical quantity:

1. Mass is defined as the quantity of matter or substance. This quantify is a function of the internal structure of the substance and of its dimensions. When a given mass is chosen, its value remains unaffected and unchanged by external influences such as the geographical location, the temperature, or the pressure. In the MKS measuring system, the standard mass unit is the kilogram.

2. Length is defined as the linear magnitude of anything as measured from end to end. The fundamental length unit in the MKS system is the meter.

3. Time is defined as the relationship which any event has to any other event as past, present, or future. The fundamental time unit in the MKS system is the second.

4. Force is defined as the external influence that sets an object in motion or that changes the direction of motion of a moving object. The fundamental force unit in the MKS system is the newton. It is equal to:

(1 kilogram X 1 meter)/(1 second/1 second)

Instructions for Review Session 2

1. Type go to review2
2. Select the review section you wish to go to from page 13
3. Note on "go to" instructions: the "go to" code is an instruction to the machine and it will not accept any ambiguity. Therefore type the "go to" code exactly as it is typed in this booklet. If it does not work, try again before calling the proctor.

You cannot change sections in the middle of a review section so be sure you instruct the machine to go to the section that you want.
The first message at the beginning of each review section will give you the content area and number of problems covered in that section. If you find that you do not want to review this section, execute another go to instruction. Once you have started on the first question, you cannot select another section until you complete the one you have already started.

Sections for review2

Pick the section you wish to review from the left hand column and type the "go to" code exactly as you see it in the right hand column.

<u>TO REVIEW</u>	<u>TYPE</u>
the general concepts of reflection of light 7 problems, 15 minutes	go to reflect
the general concepts of refraction of light 8 problems, 18 minutes	go to refract
the particle model of light 3 problems, 6 minutes	go to ltpart
the general properties of waves 4 questions, 8 minutes	go to waveprop
the behavior of waves with relation to light and the wave model of light 8 questions, 18 minutes	go to wavbehav
the PSSC film INTRODUCTION TO OPTICS 3 questions, 6 minutes	go to film201
the PSSC film SPEED OF LIGHT 4 questions, 8 minutes	go to film203
the PSSC film SIMPLE WAVES 6 questions, 15 minutes	go to film204
sample exam for this (second) hour exam 20 questions, 20 minutes	go to exam2

Here are some notation conventions we use at CAI.

1. Since we cannot use the usual degree sign as:

   30^o we type 30 □

   where the symbol □ (upper case 2) means degrees.
2. The period of a wave is symbolized by a capital T,

   period = T
3. The frequency of a wave is symbolized by a lower case f.

   frequency = f
4. The wavelength of a wave is symbolized by a capital L.

   wave length = L

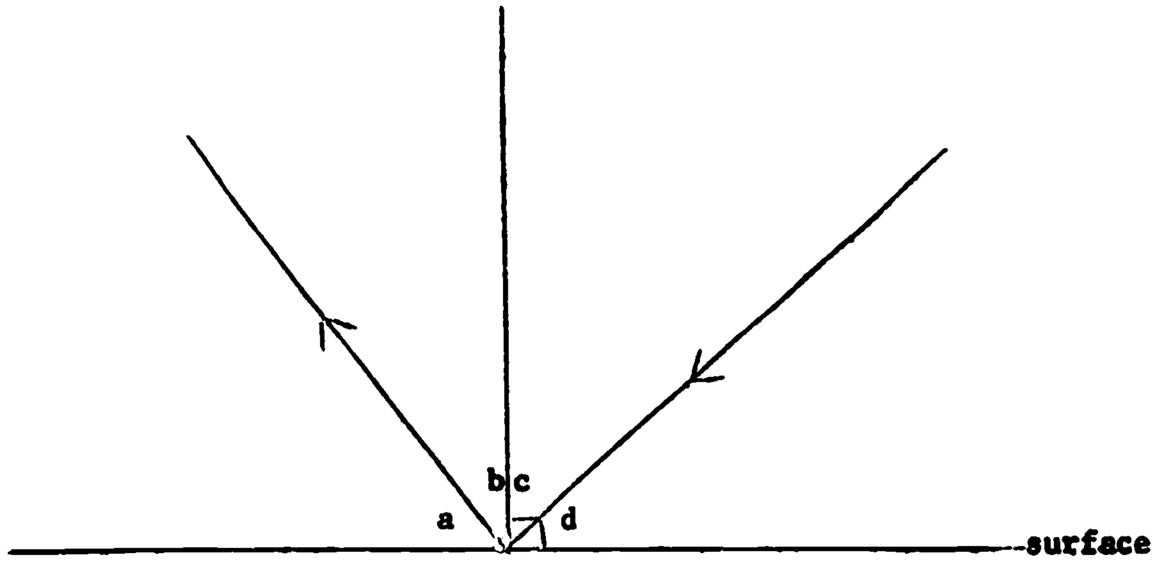


FIGURE 1

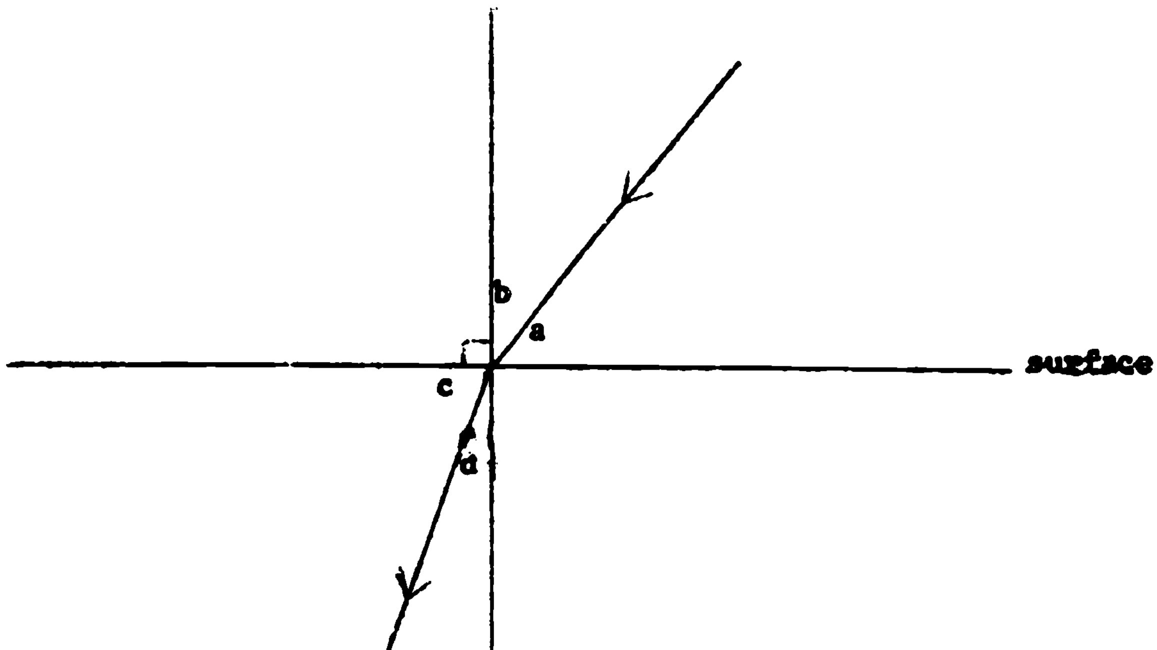


FIGURE 2

Sample Exam2b Instructions

This exam is multiple choice. There are no hints given for this exam. Type go to exam2b.

Sections for review3

Pick the section you wish to review from the left hand column and type the "go to" code exactly as you see it in the right hand column.

TO REVIEW	TYPE
the concepts of acceleration ----------------- 4 questions--8 minutes	go to accel
the relationship between --------------------- mass and weight 4 questions--8 minutes	go to mass
the concepts of momentum --------------------- 4 questions--8 minutes	go to momentum
the ideas about energy ----------------------- 4 questions--8 minutes	go to energy
the concept of work -------------------------- 4 questions--8 minutes	go to work
the concept of forces ------------------------ 4 questions--8 minutes	go to force
a sample exam III ---------------------------- 20 questions--20 minutes	go to exam3
the film "FORCES" ---------------------------- 5 questions--10 minutes	go to film301
the film "INERTIA" --------------------------- 5 questions--10 minutes	go to film302
the film "INERTIAL MASS" --------------------- 2 questions--5 minutes	go to film303
the film "DEFLECTING FORCES" ----------------- 4 questions--10 minutes	go to film305
the film "FRAMES OF REFERENCE" --------------- 5 questions--10 minutes	go to film307

the film "ENERGY AND WORK" -------------------- go to film311
5 questions--10 minutes

the film "CONSERVATION OF ENERGY" ------------- go to film313
3 questions--8 minutes

INSTRUCTIONS FOR SAMPLE EXAM3

There are no hints or explanations of wrong answers for this exam. Type go to exam3b, then signal EOB.

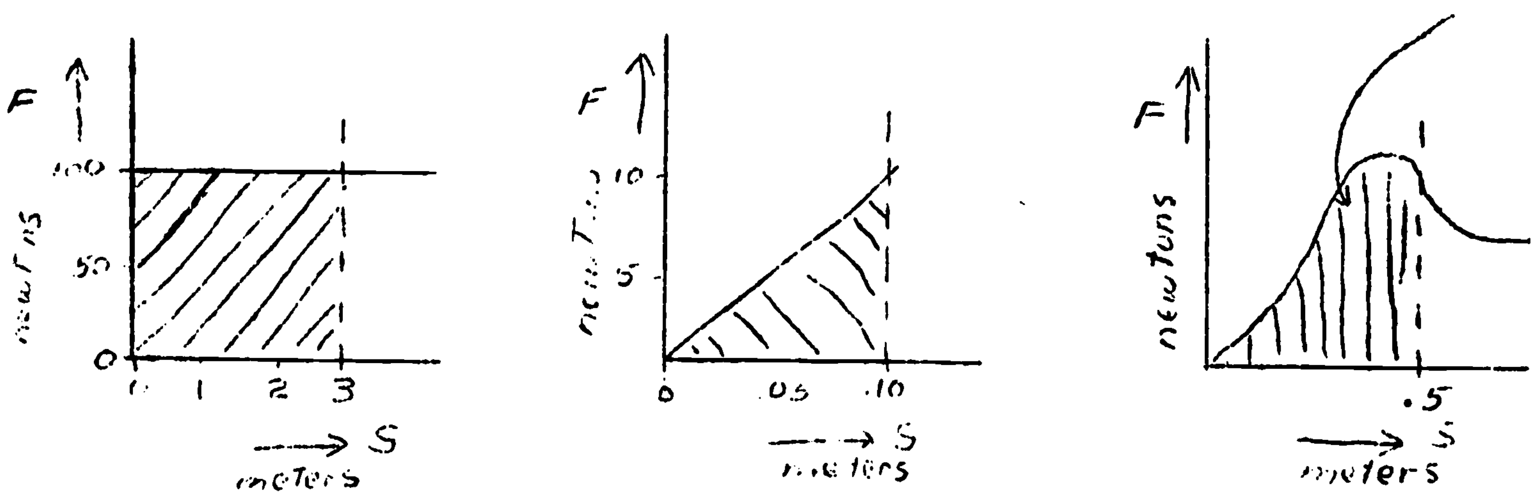
FOR PROBLEM 2 OF FILM 303 SECTION!

Acceleration of disk = 6.1 cm/sec**2
Acceleration of disk + dictionary = 4.2 cm/sec**2
Since acceleration is inversely proportional to inertia, for the same applied force, we can write:

$$\frac{\text{inertia of disk + dictionary}}{\text{inertia of disk}} = \frac{\text{acceleration of disk}}{\text{acceleration of disk + dictionary}} =$$

$$\frac{6.1}{4.2} = 1.45$$

$$\frac{\text{inertia of dictionary}}{\text{inertia of disk}} = 0.45$$



Notice that the F vs. S curve may have various shapes. Curve (A) represents a constant force, such as the force of gravity near the earth's surface. (B) might be a simple spring balance, the force being directly proportional to the amount S by which the spring is stretched from its original length. (C) is the odd-shaped curve obtained from the spring system demonstrated in the film.

INSTRUCTIONS FOR EXAM3A

Some questions in this sample exam require units in the answer. To simplify the answer form, we use certain abbreviations. When you need to express the units of an answer, use the abbreviations which follow. If you do not use these abbreviations, the machine will not recognize your answer as being correct and will count it wrong. If the answer requires units, and you do not supply them, the answer will be counted wrong.

UNIT	ABBREVIATION
kilogram	kg
meter	m
second	sec
hour	hr
newton	n
joule	joule (no abbreviation)
newton meter	joule
kg m/sec**2	n
centimeter	cm
per (as in miles per hour)	/

A deflecting force is that component of a force which is perpendicular to the velocity of a body. Dr. Frank demonstrated such a force by tying a string to a frictionless disk, giving a pull on the string at right angles to the direction of motion of the disk, and photographing the resulting motion. You probably weren't surprised that the amount of bending of the path was a function of how hard a force he pulled with. But it wasn't so obvious, until he measured the photographs, that the speed of the disk after the pull was the same as before the pull. So an important property of a pure deflecting force is that it changes the direction, but not the speed of motion. Enter EOB when you are ready to begin.

To sum up the findings:

1. Forces at right angles to a body's motion make the body move in a curved path.

2. If the force is constant in magnitude, it causes the body to move in a circle.

3. Measurements of force and acceleration in uniform circular motion and straight-line motion verified Newton's law $F = ma$.

4. If $F = ma$ holds for all motions, one may use observed accelerations to uncover the existence of forces in nature and to measure them--as Newton did in formulating his law of universal graviatation.

The data from the film is reproduced here for your convenience.

Millions of BTU/hr

Input		output	
from coal consumption	729	out of the smokestack	69
		from the condenser to Salem Harbor	360
		to electrical power	291
	729		720

The following sections are available for reviewing the materials for your hour exam 4.

TO REVIEW	TYPE
electrostatics and electric fields, 6 questions--12 minutes	go to electro
electric currents, power, and energy 4 questions--8 minutes	go to current
magnetism, magnetic fields, magnetic forces 4 questions--8 minutes	go to mag
induction 5 questions--10 minutes	go to induct
Thomson's, Rutherford's and Bohr's atom models 5 questions--10 minutes	go to atmod
Modern physics, photons, particle waves 7 questions--14 minutes	go to modps
The film "Coulomb's Experiment" 3 questions--8 minutes	go to film403
The film "Millikan's Experiment" 6 questions--15 minutes	go to film404

The film "Charges and Kinetic Energy Transfer" -- go to film409
3 questions--8 minutes

The film "Mass of the Electron" ---------------- go to film413
3 questions--8 minutes

The film "Photons" ----------------------------- go to film418
3 questions--8 minutes

The film "Interference of Photons" ------------- go to film419
4 questions--10 minutes

The film "The Franck-Hertz Experiment" ---------- go to film421
3 questions--8 minutes

To take a sample exam 4 ------------------------ go to exam4
20 questions--20 minutes

To take a final review, see page 30 of this booklet.

The following calculation was done in the film to predict the amount of kinetic energy acquired by the electrons as they are accelerated through a vacuum tube.

Total energy gained = (energy gained by 1 electron)(total number of electrons)

= (force/elem. ch.)(distance between plates)(current)(duration of current)

Or, in terms of units:

joules = (newtons/elem.ch.)(meters)(elem.ch./sec)(sec)

From the Millikan experiment film, which used the same plate separation and applied voltage, we know:

Force/elem.ch. = 1.4 X 10**-14 n

Distance between plates = 3.1 mm = 3.1 X 10**-3 m

Remembering that 1 ampere = 6.25 X 10**18 elem.ch./sec

Current = 2 X 10**-3 amp = (2)(10**-3)(6.25 X 10**18) elem.ch./sec

= 1.25 X 10**16 elem.ch./sec

Duration = 20.5 sec

Total energy gained = (1.4 X 10**-14)(3.1 X 10**-3)(1.25 X 10**16)(20.5)joules

= 11 joules

The purpose of this experiment was to determine the mass of a single electron, by accelerating it to a known speed in a cathode ray tube and measuring its deflection in a known magnetic field.

Although several calculations must be made, the basic idea is the simple one outlined by Dr. Rogers at the start of the film. If we can measure two quantities (the electron's kinetic energy and momentum), we can then solve for electron velocity v and electron mass m, as follows:

kinetic energy $1/2mv^{2} = qV$

momentum $mv = qBr$

where m - electron's mass, q = electron's charge, V = accelerating voltage,

B = magnetic field, r = radius of circular path.

Combining equations: $1/2(qBr)v = qV$ so $v = 2V/Br$

and $m = qBr/v$ so $m = qB^{2}r^{2}/2V$

In the film V and r were measured directly, B was calculated from the ammeter current (10 amperes) by the relation B = constant (current/distance from wire)

q = 1 elem.ch. V = 762 volts = $762(1.60 \times 10^{-19})$ joules/elem.ch.

r = .70 meters

$$B = \frac{5.12 \times 10^{-45}\text{n (2 wires)(5 strands/wire)(10 amp/strand)}(.625 \times 10^{19}\text{ elem.ch.)/amp}}{\text{(elem.ch./sec)}}$$

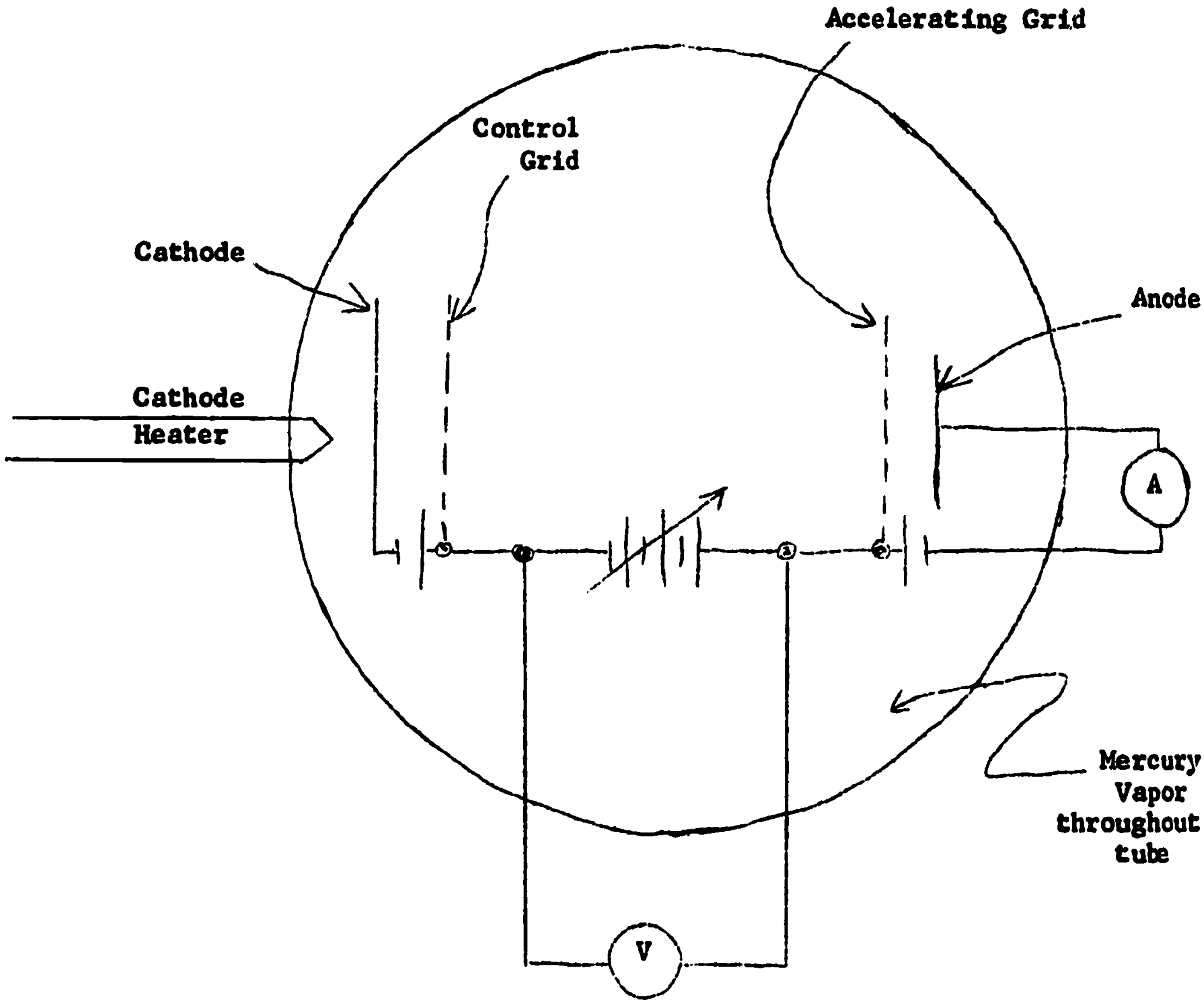
$$= \frac{2.13 \times 10^{-23}\text{ n}}{\text{(elem.ch./sec)m}}$$

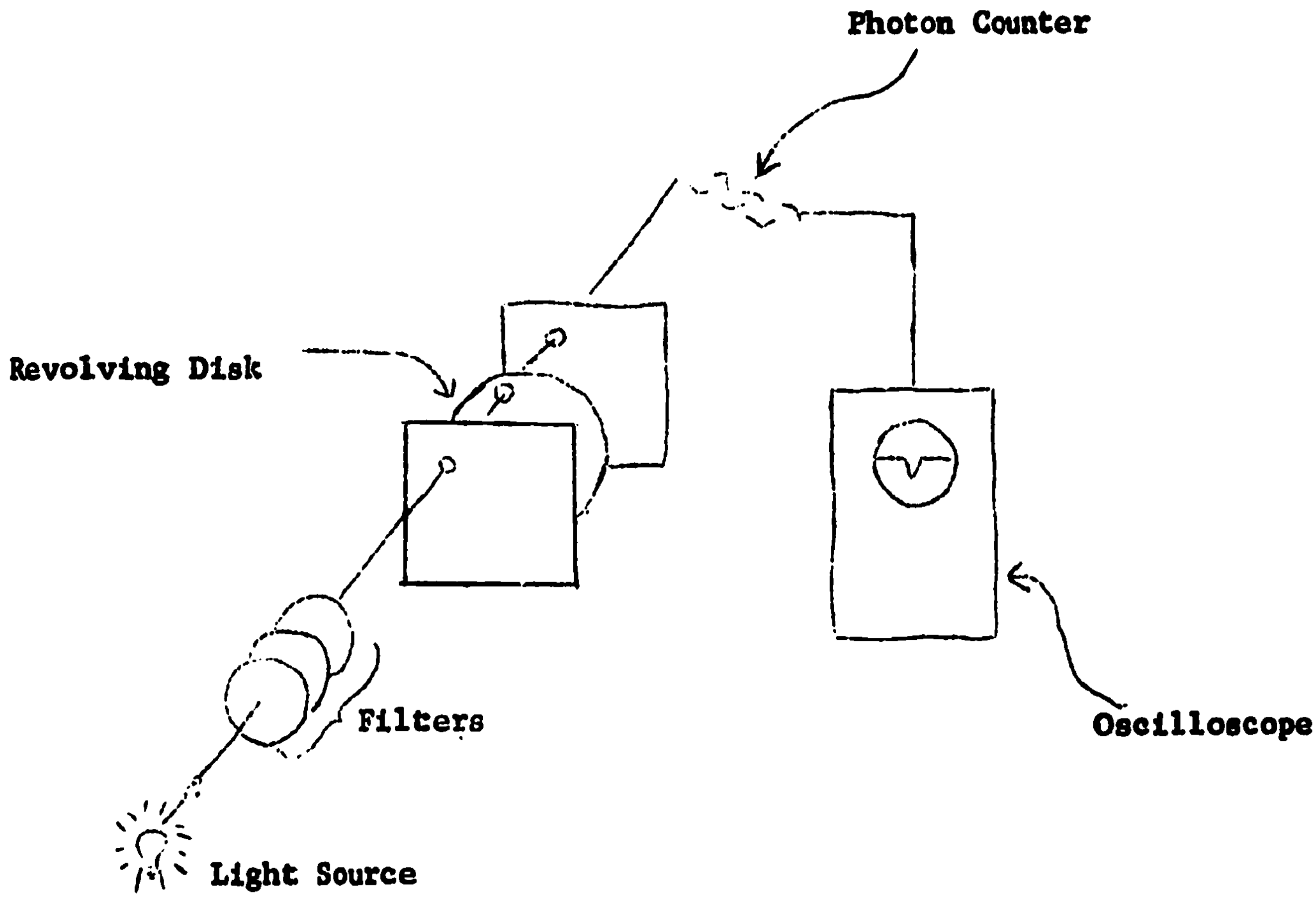
Substituting these values in the equation for m:

$$m = \frac{(1\text{ elem.ch.})\left(\frac{2.13 \times 10^{-23}\text{ n}}{\text{m - elem.ch./sec}}\right)^{2}(.70\text{ m})^{2}}{2(762)(1.60 \times 10^{-19}\text{ joules/elem.ch.})}$$

$m = 9.1 \times 10^{-31}$ kg

The electron has an extremely small mass! On the other hand, if we calculate its speed in this tube (v), it is extremely large (about 10,000 miles/sec). It is interesting that ordinary mechanics concepts such as momentum and kinetic energy relationships can be successfully used in this way-out range.


Accelerating Grid
Control
Grid
Cathode
Anode
Cathode
Heater
A
V
Mercury
Vapor
throughout
tube


Photon Counter
Revolving Disk
Filters
Light Source
Oscilloscope

Once again we have two types of sample exams. The fill-in-the-blank exam is reached by typing a. The multiple choice is reached by typing b.

If you take exam a, refer to page 20 of this booklet for instructions and abbreviations.

The following abbreviations or conventions are to be remembered and added to the list on page 20:

amperes ------------------------------ amp (not amps)

webers ----------------------------- weber (no abbreviation)

GOOD LUCK!

INSTRUCTIONS FOR FINAL REVIEW

There are two final reviews, both are multiple choice and are different from one another.

Before each question is presented to you, there will be a code which indicates where you can review similar questions should you feel the need.

The form of the code is : N xxxxxxxx

where N is either 1 or 2 and xxxxxxxx is the label of the particular section which covers the concept involved.

Because of the complexities of the computer, we have the entire physics review in two sections which are called physics1 and physics2. To get from one to the other, you must sign off, and sign on into the other by typing

go to xxxxxxxx

where xxxxxxxx is the label you saw in the question in the final review.

To get to the final review, get into physics1 and then type go to finrev.

If you don't understand, call the proctor and he will explain the procedure in detail.

PHYSICS REVIEW (1440)

Elementary Physics Problems for Homework and Review

Begin reading page 1 of the supplementary booklet and read carefully through page 3. When you have finished reading these pages, select the subject you wish to review.

Algebra

Problem 1: Simplify this expression so that the "A" is on the left side of the equation.

$$\frac{AXY}{BY} = \frac{XZ}{Z}$$

a. $A = XZ - \frac{XY}{2BY}$

b. $A = \frac{BXZY}{2XY}$

c. $A = \frac{BZ}{2}$

d. $A = 2BZ$

(ca) c. Good.

a,b,d. Incorrect. The correct way to do this problem follows:

$$\frac{AXY}{BY} = \frac{XZ}{2}$$

1. Cross multiply: $2ZXY = BYXZ$
2. Divide by everthing on the left side except "A" $A = \frac{BYXZ}{2XY}$
3. Cancel terms which are in both the numerator and denominator:

$$A = \frac{BZ}{2}$$

Problem 2: Solve for B: $\frac{(X+Y)}{AB} = \frac{(X+Y)}{3}$

a. $\frac{3}{A} = B$

b. $B = \frac{A}{3}$

c. $\frac{3X+3Y}{2AX} = B$

d. $\frac{2AX}{3X+3Y} = B$

(ca) a. Good.

b,c,d. Incorrect. Here is the correct way to do this problem:

$$\frac{(X+Y)}{AB} = \frac{(X+Y)}{3}$$

1. Cross multiply $3(X+Y) = AB(X+Y)$

2. Divide by (X+Y): 3 = AB

3. Divide by A $\frac{3}{A} = B$.

<u>Problem 3</u>: Perform the indicated operation $\dfrac{(\frac{1}{3}) \times YZ}{\frac{(3X^2)}{Z}} - \dfrac{(\frac{1}{3})\, ZX}{3X\,(\frac{X}{Z})}$

a. $\dfrac{Z^2(Y-1)}{9X}$

b. $\dfrac{Z^2(Y-1)}{(3^2)\, Z}$

c. $X^3(X)$

d. $\dfrac{XYZ}{X}$

e. $\dfrac{X}{3X^2}$

(ca) a. Well done

b,c,d. Your answer is incorrect. Here is a way to solve the problem.

1. Recognize that $\frac{3X^2}{Z}$ is the same as $3X(\frac{X}{Z})$ and hence, you already have a common denominator which you need for addition or subtraction with fractions.

2. Perform the subtraction: $\dfrac{\frac{1}{3}XYZ - \frac{1}{3}ZX}{\frac{3X^2}{Z}}$

3. Multiply by 3: $\dfrac{XYZ - Z\,X}{\frac{9X^2}{Z}}$

4. Multiply by Z: $\dfrac{XYZ^2 - Z^2X}{9X^2}$

5. Factor (Z^2) from the numerator:

6. Cancel X $\dfrac{Z^2(Y-1)}{9X}$

Problem 4: $\dfrac{(\frac{1}{X})(3Y)(\sqrt{2})}{\frac{1}{(X)(\sqrt{2})}}$

a. $6Y$

b. $6Y\sqrt{2}$

c. $\dfrac{Y(\sqrt{5})}{X}$

d. $\dfrac{3Y}{2X}$

(ca) a. Fine job.

b,c,d. Incorrect. Here is a way to do the problem.

1. Invert and multiply $(\frac{1}{X})(3Y)(\sqrt{2}) \times (X)\ \sqrt{2} = 1(3Y)(2) = 6Y$

Problem 5: Solve this equation for X: $3X + 2 - 4X - 18 = 9X + 3 - 4X + 2$

a. -3

b. $\dfrac{11}{4}$

c. $\dfrac{-7}{2}$

d. $\dfrac{11}{6}$

(ca) c. Good.

a,b,d. Incorrect. Here is a method for solving this problem:

$$3X + 2 - 4X - 18 = 9X + 3 - 4X + 2$$

1. Combine terms on each side: $-X - 16 = 5X + 5$
2. Add 16 to both sides: $-X = 5X + 21$
3. Subtract 5X from both sides: $-6X = 21$
4. Divide by negative 6: $X = \dfrac{-21}{6}$
5. Divide numerator and denominator by 3: $X = \dfrac{-7}{2}$

Problem 6: Solve for Y: $3 + (\frac{3X}{5})(\frac{2X}{5}) = Y(\frac{1}{Y})Y + 3$

a. $Y = \frac{3X}{5}$

c. $Y = \frac{6X}{5}$

b. $Y = 6^2(\frac{X}{5})$

d. $Y = \frac{6X^2}{5^2}$

(ca) d. Well done.

a,b,c. No you made an error somewhere in calculation. Here is a way to proceed:

$$3 + (\frac{3X}{5})(\frac{2X}{5}) = Y(\frac{1}{Y})Y + 3$$

1. Subtract 3 from both sides: $(\frac{3X}{5})(\frac{2X}{5}) = Y(\frac{1}{y})y$

2. Carry out the indicated multiplication: $\frac{6X^2}{5^2} = Y$

Problem 7: Solve for X: $3X - 2 = 5(X + 4)$

a. -9

c. +9

b. -11

d. +11

(ca) b. Correct.

a,c,d. Incorrect. See if you can find your error by following this:

$$3X - 2 = 5(X + 4)$$

1. Multiply the right hand expression: $3X - 2 = 5X + 20$
2. Subtract 5X from both sides: $-2X - 2 = + 20$
3. Add 2 to both sides: $-2X = 22$
4. Divide by -2: $X = -11$

Problem 8: If X = 3 and Y = 4, what is the value of

$$Z = \frac{X}{X} + (\frac{2Y}{y}) + XY + (0)(X) + (Y + 0)$$

a. 21 c. infinity

b. 23 d. 19

(ca) d. Good.

a,b,c. Nope. Follow this and you will see why the answer is 19:

1. Replace values: $Z = \frac{3}{3} + 2\ (\frac{4}{4}) + (3)(4) + (0)(3) + 4 + 0$

2. Calculate: $Z = 1 + 2 + 12 + 0 + 4$

3. Add: $Z = 19$

Problem 9: A = 5 and Y = 2, what is the value of X

$$(A-5)(X) = 3YZ$$

a. 0 c. cannot be determined

b. infinity d. $\frac{-20}{9Z}$

(ca) c. Right. A-5=0 and it is inadmissable to divide by zero in algebra which you would have to do in order to have X alone on the left side of the equation.

a,b,d. No, the answer is c. The reason is that A-5=0 and it is inadmissable to divide by zero in algebra which you would have to do in order to have X alone on the left side of the equation.

Problem 10: If Charlotte is 3 years younger than Ken and she is $\frac{5}{8}$ Ken's age, then how old is she?

a. 20 c. 18

b. 3 d. 5

(ca) d. Very good.

a,b,c. No, Charlotte is 5 and here is how you figure it out by placing the information in equation form.

Charlotte is three years younger than Ken $C + 3 = K$

Charlotte is also $\frac{5}{8}$ Ken's age $C = \frac{5}{8}K$

Hence, in equation I can be replaced by the value of K from equation II.

Then, $C = \frac{5}{8}(C + 3)$

$C = 5\frac{c + 15}{8}$

$8C = 5C + 15$

$3C = 15$

$C = 5$

Problem 11: Given $W = (\frac{1}{2})K(X^2)$; and that W is 5 when X is 3, what is W?

a. 4.5 c. 22.5

b. $\frac{125}{9}$ d. 9

(ca) b. Excellent

a,c,d. No, you have made an error. Here is a way to solve this problem.

1. Substitute W=5 and X=3 into given equation and compute.

$$5 = (\frac{1}{2})K(3^2)$$

$$5 = (\frac{1}{2})K(9)$$

$$\frac{5}{4.5} = K$$

2. Now substitute X=5 and $\frac{5}{4.5} = K$ into original equation and solve for W:

$$W = (\frac{1}{2})(\frac{5}{4.5})(5^2)$$

$$W = (\frac{1}{2})(\frac{5}{4.5})(25)$$

$$W = \frac{125}{9}$$

<u>Problem 12</u>: Convert 25.4 km to inches, using the following facts:

1 inch = 2.45 cm and 1 km = 100,000 cm.

a. 1,000,000 in.

b. 100,000 in.

c. 254,000 in.

d. 2,540,000 in.

(ca) a. Very good.

b,c,d. Incorrect. Here is the method by which you can do this conversion:

$$\frac{25.4 \text{ km}}{2.54 \text{ km}} \times \frac{100,000 \text{ cm}}{2.54 \text{ cm}} = 1,000,000 \text{ in.}$$

The rationale for this problem is that there is 100,000 cm in a km so to find how many cm in 25.4 km you multiply. Then, because there are 2.54 cm in one inch you divide by 2.54 to see how many inches there are in 2,540,000 cm.

NOTE: The km and cm units cancel.

Problem 13: If the acceleration of gravity is G=9.8 meters/sec^2, what is it in miles/hr^2. Use 1 mile (MI)= 5280 ft. and 1 meter=3.2 ft. Don't forget there are 3600 seconds in 1 hour.

a a. 5280 MI/hr^2

b. $\frac{9.8 \times 3600^2}{3.2 \quad 5280}$

c. $\frac{9.8 \times 3.2}{5280}$

d. 11,186 MI/hr

(ca) c. Very well done.

a,b,d. Incorrect. Here is a way to solve the problem:

Convert meters to feet: 9.8 x 3.2 (There are 3.2 ft. in a meter).

Convert feet to miles: $\frac{9.8 \times 3.2}{5280}$ (There are 3600 seconds in 1 hr.

Convert seconds (squared) to hours (squared): $\frac{(9.8 \times 3.2)}{3600 \times 3600}$

Summary: 9.8 x 3.2 x 3600 x 3600 miles/hr/hr

This completes the albegra practice section. You can see by the print out that you have missed (number missed is printed), of the 13 problems. If you would like to continue reviewing physics problems, type the word select. Otherwise, type sign off and notify the proctor.

Units

Read page 11 of the supplementary booklet wyile the typewriter prints the introduction to this section. As you will see in this review and subsequent work involving the physical sciences, the units of measurement play an important role in this work. Although you may not understand the terms presented here, you will eventually have to work with them in this course. Our object to presenting them at this time is to give you an understanding of the technique of working with the units of an equation before you work with the numbers--just to be sure you are working with the appropriate equation.

To continue, are you familiar with the meaning of "units" or "units of measure?" (Type yes or no.)

(ca) Good. The units you will need to use in Physics 107 are listed below. To refer to the "units or "units of measure" of a quantity is to refer to the label assigned to this quantity. Some examples are shown below--with the units of the quantity printed in red. Examples of units of measure for

Time	25 seconds	Wages	$2.00 per hour
Speed	75 miles per hour	Mass	50 kilograms
Length	10 meters	Force	25 newtons
	100 yards		50 pounds

To measure

Length or distance		meters
Time	use	seconds
Mass		kilograms

All other units or measure are combinations of the three basic quantities--length, mass and time.

Force or Weight	Newtons
Work Done	Joules
Energy or Power	Joules
Electrical Charge	Coulombs
Electrical Current	Amperes
Electrical Energy	Volts
Electrical Work or Power	Watts or Joules

The problems which follow are examples of the need to work with units of measure. Three basic things to remember about units:

1) Units are treated in a normal algebraic manner.
2) Units can cancel as algebraic quantities.
3) The units on both sides of a relationship (equation) must be the same.

Complete the following:

Problem 1: Miles X Kilometers/Miles X Meters/Kilometers =

a. Miles/Meter
b. Kilometers/Miles
c. Meters
d. need help

(ca) c. Good. You remembered the 3 basic points about units.

Let's look closely at the problem, first, we multiply the first two terms (Miles X Kilometers/Miles). The miles cancel and we are left with Kilometers. Then multiply kilometers by the third term (Kilometers X Meters/Kilometers) and we get meters. Now what is the answer?

Problem 2: Suppose that you were X miles from your destination and you had Y hours to get there, how fast would you have to travel?

a. Y hours X miles

b. X miles/Y

c. Y hours/miles

d. Don't know

(ca) b. Good. You know that speed is measured in length per unit time so you don't even need to know numbers to be able to answer.

(wa) a. No. The units of speed are length per unit time. Answer correctly.

(wa) d. You know that speed is usually shown as length per unit time. Now try again.

This concludes the review of units and units of measure. In summary, every essential property, such as the velocity, direction, volume or diameter that enters into the description of physical phenomena has its own units which differentiate it from other properties. Although every physical quantity has its own units, one will notice that all such quantities are made up of a very limited number of fundamental dimensions. When an equation representing a physical phenomenon is written down it is absolutely necessary that the equation, be dimensionally homogeneous. That is, both sides of the equality sign must be expressed in the same units. If they are not, one can be sure that some important quantity was lost or misplaced in the derivation. Select the section you wish to review. Refer to pages 12 and 13 of the booklet.

Notation

Powers of ten or scientific notation

Read the scientific notation introduction on page 5 of the supplementary booklet.

Problem A: Let's practice using the notation which is particular to this typewriter. Refer to typing practice problem A, page 5:

(ca) a. Good.

(wa) b,c. No, try again. Remember two asterisks designate the power-of-ten.

Problem B: Typing practice.

a. 1.602×10^4

b. 1.602×4^{10}

c. 1.602×10^4

(ca) c. Fine.

(wa) a,b. No, try again. Remember two asterisks designate the power-of-ten.

Order

The following six problems are designed to familiarize you with the concept of orders of magnitude. They will be followed by eight problems dealing with calculations in scientific notation. Signal to begin.

Problem 1: Which would you rather have, 3 kilobucks or one megacent? Type either "one megacent" or "3 kilobucks."

(ca) one megacent or megacent or a megacent.

Place these in scientific notation, convert to dollars and answer the question. Apparently you don't want to be rich. Three kilobucks are 3×10^3 dollars and one megacent is 1×10^4. Now type in your answer.

Problem 2: The order of magnitude (in terms of dollars) of the correct answer to the above question is:

a. 10^4

b. 10^3

c. 10^5

(ca) a. Well done.

(wa) b. No, 10^3 is the order of magnitude of the wrong answer. Try again. Remember that the order of magnitude is the power of ten cloest to the number. Now answer correctly.

Problem 3: There are about 73,000 people living in Leon County, of whom about 48,000 live in Tallahassee. The order of magnitude of the number of people living in Leon County outside Tallahassee is

a. 10^5

b. 10^4

c. 10^3

(ca) b. Right

(wa) a. No, the number of people living in Leon County outside Tallahassee is 25,000 which is much less than 10^5 or 100,000.

(wa) c. No, the number of people living in Leon County outside Tallahassee is 25,000 which is much greater than 10^3 or 1,000.

HINT: In good scientific notation, write the number of people living outside Tallahassee--in Leon County--the nearest power-of-ten to that number is the order of magnitude. Now answer correctly.

<u>Problem 4</u>: What is the order of magnitude of the number of seconds in a century?

a. 10^9

c. 10^6

c. 10^{11}

(ca) a. Good.

HINT: You need the number of years in a century, the number of days in each year, the number of hours in a day, the number of minutes in an hour, and the number of seconds in each minute.

Here is one way of working the problem:

Number of seconds per century = 60 seconds/minute X 60 minutes/hour X 24 hours/day X 365 days/year X 100 years/century (Note that we can ignore the extra days of leap years because the order of magnitude of the number of seconds in a day is very much smaller than the order of magnitude of seconds in a century). The order of magnitude of the seconds in a day is 10^5, compare this to the correct answer and see why we can ignore the extra day in leap years:

$= (6.0 \times 10^1) \times (6.0 \times 10^1) \times (2.4 \times 10^1) \times 3.65 \times 10^2) \times (1.0 \times 10^2) \times$

(1.0×10^2) seconds/century.

Separate out powers-of-ten:

$= (6.0) \times (6.0) \times (2.4) \times (3.65) \times (1.0) \times (10^{1+1+1+2+2})$ seconds/century

$= 315.36 \times 10^7$

$= 3.1536 \times 10^9$

Now find the order of magnitude of this product and answer the question correctly.

Problem 5: What is the order of magnitude of the repeating fraction $\frac{3}{7}$.

a. 10^0 c. 10^{-1}

b. 10^1

(ca) c. Correct.

(wa) a,b. Wrong. Remember that the order of magnitude of a number is the nearest power-of-ten to the number involved. Now find the right answer and type its letter.

Read page 5 of the supplementary booklet.

Problem 6: If the national debt were 10 million dollars, what is the order of magnitude of the national debt in cents?

a. 10^7 c. 10^9

b. 10^8

(ca) c. Good.

(wa) a. Wrong. That is the order of magnitude of the national debt in dollars. Now type in the letter of the correct answer.

(wa) b. No. That is the order of magnitude of the national debt in dimes. Now type in the letter of the right choice.

HINT: Convert to scientific notation, then convert to cents and consider the power-of-ten.

This ends the review problems dealing with order of magnitude. Signal to begin the problems dealing with scientific notation calculations. If you wish to go to another review section, follow the directions on page 3 of the booklet.

The eight problems which follow are designed to give you practice in using scientific notation to perform numerical calculations. Read page 5 of supplementary booklet.

Problem 1: In the best scientific notation, $4.7 \times 10^{-7} \cdot 7 \times 10^{-3} =$

a. $.4 \times 10^{-5}$ c. 4×10^{-2}

b. $.4 \times 10^{-2}$

(ca) c.. Very good.

(wa) a. Remember, before adding or subtracting, numbers must be written
HINT: in terms of the same power-of-ten. Try writing both numbers in terms of 10^{-2}. Now enter the correct answer.

(wa) b. Almost, but not quite. This problem could be re-written as follows:

$$4.7 \times 10^{-2} - .7 \times 10^{-2}$$

Problem 2: One method of finding the length of the hypotenuse of a right triangle when the lengths of the other two sides are known is to take the square root of the sum of the squares of the two known sides. For example, in a right triangle with one side 3 meters long, another side 4 meters long, the hypotenuse is found by taking the square root of $(3^2) + (4^2)$ or

$$\sqrt{9 + 16} = \sqrt{25}$$

$$\sqrt{25} = 5 \text{ meters.}$$

Suppose that you wish to find the shortest distance to a point which is 30 miles north and 40 miles west of your position. What is the distance?

a. 70 miles

b. 10 miles

c. 50 miles

(ca) c. Right.

(wa) a. That is not the shortest distance to that point. Draw a picture if necessary, work the problem using the information given above and answer correctly.

(wa) b. No. Re-read the information given and try again.

HINT: One side of the triangle is 30 miles, the other side is 40 miles. Square each term, add their squares.

Problem 3: The kinetic energy of a moving object is expressed by the relationship

$$KE = (1/2)\ M(V^2)$$

where M equals mass, and V equals velocity. What is the kinetic energy of an automobile of mass 1000 kilograms and velocity whose magnitude is 30 meters per second.

a. 1.5×10^4 kilogram meters squared per second squared.
b. 4.5×10^5 kilogram meters squared per second squared.
c. 45×10^4 kilogram meters squared per second squared.

(ca) b. You do good work.

(wa) a. No. Be more careful when you square the velocity. Try again.

(wa) c. That's the right answer, but it is not expressed in good scientific notation. Revise it and type in the correct response.

HINT: Let's go through the problem step by step:

1. Substitute the given values into relationship:

$$KE = 1/2 \text{ X } 1000 \text{ kg X } (30 \text{ m/sec}^2)$$

2. Convert to scientific notation.

$$KE = 1/2 \text{ X } 1 \text{ X } 10^3 \text{ kg X } (3 \text{ X } 10 \text{ m/sec}^2)$$

3. Square the velocity.

$$KE = 1/2 \text{ X } 1 \text{ X } 10^3 \text{ kg X } (9 \text{ X } 10^2)(\text{m/sec}^2)$$

4. Multiply, following the rules of scientific notation.

$$KE = 4.5 \text{ X } 10^5 \text{ kg } (\text{m/sec}^2)$$

Notice that the whole process is a simple substitution of values into a functional relationship and the arithmetic processing of these values. Work the problem again by yourself and type the correct response.

Problem 4: In best scientific notation, $(400^2 + 300{,}000)$ is

a. $4.6 \text{ X } 10^5$

c. $1.4 \text{ X } 10^5$

b. $7 \text{ X } 10^5$

(ca) a. Very good.

(wa) b,c. No. I think you have made a mistake in your arithmetic. Work it again, and type in the right response.

HINT: Here is one way of working this problem. First, convert everything to scientific notation.

$$(4 \text{ X } 10^2)^2 + 3 \text{ X } 10^5$$

Second, square the first quantity

$$16 \text{ X } 10^4 + 3 \text{ X } 10^5$$

Third, adjust the first quantity so that it is in good scientific notation

$$1.6 \times 10^5 + 3 \times 10^5$$

Fourth, check to see if both numbers are in terms of the same power-of-ten. If they are not, adjust the numbers so that they are expressed in the same power-of-ten. Then go through the adding procedure as outlined on page 5A of the supplementary booklet. Do this and then answer correctly.

Problem 5: Using scientific (powers-of-ten) notation, calculate the following:

$$.00418 \times 39.7$$

Choose the correct answer expressed in scientific notation form.

a. 1.61×10^{-1}

b. 1.66×10^{-1}

c. .166

(ca) b. Very good. Your calculation was exactly correct.

(wa) a. Your error indicates that you did not round off your arithmetic properly. Be more careful in the future. Enter the correct answer now.

(wa) c. This is the correct answer, but it is not expressed in scientific notation. Enter the correct answer now.

Problem 6: Choose the correct answer in the proper scientific notation form for this problem:

$$648{,}000 \times 3250.00$$

a. 2.10600×10^9

b. 2.106×10^6

c. 21.1×10^8

(ca) a. Well done, a is the proper solution.

HINT: Check the powers-of-ten you are working with.

(wa) b. Wrong. Try your calculations again--be more careful.

(wa) c. No, this answer is incorrect. The decimal point is placed such that the number is not expressed between unity and ten. This is incorrect notation.

Problem 7: Notation-form answer.

$$\frac{.3650}{.01520}$$

a. 2.401×10^1

b. 2.401×10^2

c. 2.430×10^1

(ca) a. Excellent. Your division utilizing scientific notation is apparently quite accurate.

HINT: Read page 5 of the supplementary booklet.

(wa) b. Wrong. Better learn to count decimal places with more accuracy. Try again.

(wa) c. Your arithmetic could use improvement. Calculate over and try again.

Problem 8: Calculate the following utilizing scientific notation.

$$\frac{10.0 \times 10.0}{1}$$

a. 100

b. 1.00×10^3

c. 1.0×10^2

(ca) c. Good job. Apparently zeros don't fool you as easily as they fool me.

HINT: Set all terms, in the expression, into scientific notation.

(wa) b. Zeros can be tricky. Try again.

(wa) a. This is the correct number but it is not in scientific notation form. Select and enter the correct answer.

Problem 9: If you feel you have had a great deal of trouble with these problems in scientific (powers-of-ten) notation your trouble probably lies in one of two areas (1) understanding scientific notation or, (2) arithmetic. If the problem is arithmetic, friend, I'm sorry, you'll have to get that on your own. If your trouble is understanding and working with scientific notation refer to pages 14-21 of your text Elementary Physics, Van Name, Jr.

This ends the scientific notation review section. If you wish to review other sections, follow the instructions on page 3 of the supplementary booklet. Otherwise, go to the sample exam (see page 4 of the booklet for directions).

<u>Scale</u>

SCALE PROBLEMS

This is the start of the review of mathematical functions and scaling principles. Read page 6 of your supplementary booklet for directions to this review.

<u>Function</u>

The four problems which follow will help you understand how well you can work with mathematical functions. You will find them helpful in the review of scaling theory. Read page 6 of supplementary booklet.

<u>Problem 1</u>: In the relationship expressed by Y = 2x, each value assigned to x determines a value of Y. Thus Y is a function of x. This particular function is:

a. a linear function

b. a quadratic function

c. a cubic function

(ca) a. Excellent.

(wa) b. No. If this were a quadratic function, Y would vary as x^2.

(wa) c. No. If this were a cubic function, Y would vary as x^3.

HINT: A cubic function implies that something varies as the third power of something else, just as the volume varies as the cube of the exterior dimensions. A quadratic function indicates a variance of one thing as the square of another; for example, the area of a square piece of land 2 miles on a side is $(2 \text{ miles})^2$ or four square miles. A linear function varies by the same factor that another quantity varies, just as the momentum of an object varies as its velocity. NOTE: That functions can vary directly or inversely for example:

Y = 2x, Y varies directly as x times a constant

Y = 1/2x, Y varies inversely as x times a constant.

<u>Problem 2</u>: The area contained in a circle is proportional to:

a. the radius of the circle

b. the square of the radius of the circle

c. the cube of the radius of the circle

(ca) b. Correct

(wa) a. Incorrect. Remember that for a circle, $A = (Pi) X (R)^2$ Now answer the question correctly.

(wa) c. Sorry, but the volume of a sphere is proportional to the cube of the sphere's radius; here we are only looking for the area of a circle.

HINT: If you were ordering vinyl tile to cover a floor area in your home, would you measure the area to be covered in feet, square feet, or cubic feet.

Problem 3: If the temperature (T) of a gas is increased but its volume is kept constant, the pressure (P) on the walls of its container will be given by the relationship P = cT. This means that if the temperature is tripled, the pressure of the walls will

a. increase

b. decrease

c. remain the same

(ca) a. Right you are.

(wa) b,c. No, the relationship implies that if the temperature is increased while the volume is kept constant, the pressure will also increase by a proportional amount. Now type in the correct answer.

Problem 4: In a certain experiment it is found that the weight of a piece of lead is a function of its volume. This means that

a. no matter what their volumes, all pieces of lead have the same weight.

b. two pieces of lead with the same volume will have the same weight.

c. it is never possible to determine the weight of a piece of lead if you know its volume.

(ca) b. Correct.

(wa) a. No, that the weight is a function of the volume means that the value of the weight depends on the value of the volume.

(wa) c. No, since weight is a function of the volume, for any volume the weight can be calculated if the constant of proportionality is known.

HINT: Come on, now! The question is a hint.

This completes the review of mathematical functions.

Scaling

The six problems which follow are centered around the theory of scale models.

Problem 1: A certain animal is scaled down by a factor of 1/10. As a result, his

a. original weight is reduced to 1/100, his original strength to 1/1000

b. original strength and weight are reduced to 1/100

c. original strength is reduced to 1/10, his original weight to 1/1000

d. original weight is reduced to 1/1000, his original strength to 1/100

e. I do not understand.

(ca) d. Very good.

(wa) abc. No your answer is wrong. Remember that the strength of bones increases or decreases by the square of the scaling factor while the weight of the animal increases or decreases by the cube of the scaling factor. Try again.

HINT: The following is an example to help you to understand that the strength of animal bones increases or decreases by the square of the scaling factor and the weight of an animal increases or decreases by the cube of the scaling factor. To scale an animal to 1/5 its size would be to make its overall and proportional sizes (arms, legs, etc) 1/5 their actual size. By so doing the animal would be 1/25 as strong and 1/125 as heavy. This assumes using the same bone and flesh structure as the original animal. Enter the correct answer now.

Problem 2: Let's assume you wanted to make a model home of the same structural materials you planned to use to construct a new house and you wanted to make it 1/20 of the actual size so you could place it on a table. As a result, the model:

a. would have a weight 1/1000 of the real weight of the house and the strength would be 1/100 of the real strength

b. would have a weight of 1/8000 of the real weight of the house and the strength would be 1/400 of the real strength

c. would be 10 times as strong and 1000 as heavy

d. would be 400 times as strong and 1/8000 as heavy

e. I do not understand.

(ca) b. Correct

(wa) acd. Your answer is incorrect. Refer to pages 48 to 51 of the text <u>Physics</u>.

HINT: A good discussion of scaling can be found in <u>Physics</u>, by the Physical Science Study Committee, pages 40 to 51.

<u>Problem 3</u>: Why would it be physically impossible for the Brobdingnagian giants in Gulliver's Travels to actually exist?

a. Not enough food would be available to satiate their appetites.

b. Because the weight-to-strength ratio of their bones would not enable them to support their own bodies.

c. Because their proportional strength would be too great to support their weight.

d. Because Gulliver's Travels is a fairy tale.

(ca) b. Good. You seem to have the general concept of scaling.

(wa) a,c. No, you'd better go back to the <u>Physics</u> textbook by the Physics Science Study Committee and review scaling. The correct answer is B.

HINT: Remember, bone strength varies as the <u>square</u> of the scaling factor while weight varies as the cube of the scaling factor.

(wa) d. Very funny. Now enter the correct answer choice.

Problem 4: A gorilla 5 feet tall with legs 10 inches can just barely support his 1000 pounds weight. If his height were increased to 10 feet, the thickness of his legs to 20 inches, and all his other linear dimensions were doubled, he would

a. Still be able to support himself because his strength and weight would both be doubled.

b. Collapse because his weight would be 8000 pounds, but he would only be four times stronger.

c. Collapse because he would weigh four times as much but only be four times stronger.

(ca) b. Good, you seem to understand scaling fairly well.

(wa) a,c. No, remember that cross-sectional area is proportional to the square of length, and therefore strength increases with the square of the scaling factor since strength is proportional to cross-sectional area. Volume is proportional to the third power of length, therefore mass increases with the third power of the scaling factor, since mass is proportional to volume. Now answer correctly.

Problem 5: A hummingbird which weighs 3 ounces can just barely eat fast enough to keep itself alive. If its linear dimensions (length, width, and height) were reduced by one-half, it would

a. Die because it would be losing heat one-fourth as fast but only be generating it one-eight as fast.

b. Die because it would be losing heat one-half as fast but only generating it one-fourth as fast.

c. Still keep alive because it would be generating heat one-fourth as fast but only be losing it one-eighth as fast.

(ca) a. You are quite correct. Now you see why Mother Nature made Hummingbirds the size they are.

(wa) b,c. No. The heat loss is proportional to the area, which is proportional to the square of the linear dimensions, therefore heat loss is proportional to the square of the scaling factor. Heat production is proportional to the volume which is proportional to the cube of the linear dimensions, therefore heat production is proportional to the cube of the scaling factor. Now try again.

Problem 6: A sphere, A, of plastic has a mass of 10 grams. Another sphere, B, of the same plastic has a mass of 10,000 grams. What is the scaling factor; i.e., what is the ratio of the diameter of B to the diameter of A?

a. 10

b. 100

c. 1/100

(ca) a. Correct.

(wa) b,c. The ratio of the mass of B to the mass of A is 10,000 grams/ 10 grams = 1000. Since mass is proportional to volume, the ratio of the volumes is also 1000. Volume is a function of the third power of the scaling factor, therefore the scaling factor is the cube root X 1000, which is 10. (10 X 10 X 10 = 1000). Type in the correct letter.

This concludes the review section on scaling. If you would like to review more problems on other topics, read page 3 of the supplementary text. Otherwise, follow the directions on page 4 of the supplementary text.

Films1

The following sections are designed to help you review the material content of the three films shown in class these first few weeks. Read page 8 of the supplementary booklet for a brief introduction.

Film104

The following questions are directed toward the content of the film "Measuring Short Distances".

Problem 1: An important word which refers to the ability to detect or distinguish small separations between two objects and which was used extensively in this film is ______________.

(ca) resolution. Very good.

(wa) No. Magnification refers to the power of microscope--not a quantitative ability of the device. Think hard and answer the question again.

HINT: If the object you see with the instrument is fuzzy and not very clear, we say the instrument has poor or inadequate r______________.

Problem 2: Refer to the chart on page 8 of the booklet. Which instrument would most likely distinguish the smallest objects, such as molecules?

(ca) B. Your understanding seems to be quite clear. Type the letter associated with the instrument which measures the smallest objects.

HINT: Remember, resolution is measured in units or length and, when we speak of the highest or greatest resolution, we refer to the smallest or shortest distance which the instrument can distinguish. Type in the correct answer.

Problem 3: Let's see if you recall the various instruments discussed in the film; Instruments with various resolutions were described in the film. They were:
1. Electron microscope
2. Filed emission ion microscope
3. Optical (or light) microscope
4. Filed emission electron microscope
Let's see is you recall which of these has the lowest resolution. (Type in 1, 2, 3 or 4.)

(ca) 3. Right. It's resolution is limited by the wavelength of visible light.

(wa) No, of these four, the optical microscope has the smallest resolution, because it is limited by the wavelength of visible light. Type in the correct numeral.

Problem 4: Name which instrument is the ordinary microscope used in every biology lab.
1. the electron microscope
2. the field emission ion microscope
3. the optical microscope
4. the field emission electron microscope

(ca) 3 Right.

(wa) The optical microscope is the right answer. It is well suited for this use, having sufficiently high resolution for most purposes and not requiring elaborate equipment or power supplies. Type in the correct answer.

Problem 5: If equipment and money were no object, would it be desirable to have the highest resolution instrument instead of the optical microscope for all laboratory work?

(ca) No. You're right. It certainly would not.

Such a high resolution instrument would examine only a very small area of the specimen at a time, in most cases, you would not be interested in such fine structure, but would need a "field" that is thousands of times larger than atomic distances in order to study a reasonable area of the specimen at a time.

This completes the review of the film "Measuring Short Distances."

Film106

Problem 1: Rope A has three times the diameter of Rope B. They are made of the same material. A is _______ as strong as B.

a. three times

b. nine times

c. one-tenth

(ca) B. Very good. Let's do another one.

Strength is a function of the cross-sectional area. Since area is proportional to the square of length, it increases with the second power of the scaling factor (in this case, three). Therefore, A is (three to the second power) nine times as strong as B. Try again.

Problem 2: A little boy is one-half the height of his father, so his weight must be about _______ his father's weight.

a. one-half

b. one-fourth

c. one-eighth

(ca) c. Excellent. We're ready to go on.

Remember, weight is proportional to volume. Volume is proportional to the third power of length and therefore increases or decreases as the third power of the scaling factor (which in this case is one-half). So the boy weighs (one-half times one-half times one-half) or one-eighth as much as his father. Be sure you're clear on this so we can progress. Enter the correct answer.

Problem 3: In the film, two putty bars were molded, one ten times larger than the other in each dimension. Which one of the bars was too weak to support its own weight? (Larger or Smaller)

(ca) Larger Right!

(wa) Smaller

It was the larger bar that collapsed. Compared to the smaller bar, it was (ten to the second power) or 100 times stronger, but (ten to the third power) or 1000 times heavier, and was therefore not strong enough to support its own weight. Try again.

Imagine yourself constructing an arch out of a small piece of putty (or cookie dough) and a large piece of the same material. Which piece would collapse? Now answer larger or smaller.

<u>Problem 4</u>: This happened because the ________ of the bar increases with the THIRD power of the scaling factor, while the strength, being a function of the cross-sectional area, increases only with the ________ power of the scaling factor. (Type in the two words which correctly fill the blanks.)

(ca) weight, second
Good, let's continue.

The <u>weight</u> of the bar increases with the third power, the <u>strength</u> with the second power. The larger bar is 1000 times heavier, only 100 times stronger. Now type in the answers.

<u>Problem 5</u>: Remember the large and small safes, one ten times larger in each dimension than the other? The large one is ________ times heavier than the smaller one.

(ca) 1000
Exactly

The larger one is (ten X ten X ten) or 1000 times heavier. Enter the correct answer.

<u>Problem 6</u>: The nylon rope on which the safe is hung therefore needs to be 1000 times stronger. How much larger diameter need the rope have?

a. 10 times

c. 100 times

b. square root of 1000 times

(ca) b. Very good.

(wa) a. No, since strength increases with the square of scaling factor, this would only be 100 times stronger, and we need a rope 1000 times stronger. Try again.

(wa) c. Strength increases with the square of the scaling factor. Therefore if we do as you suggest, we would have (100 to the second power) or 10,000 times, which is more strength than we need. Try again.

HINT: Remember that we've been telling you about the relationship of strength and scaling factor.

Problem 7: King Kong would have to be a lot sturdier than shown in the movie to support his own weight. Since he is 50 times taller than normal, his weight is how much greater?

a. 50 times

b. 50^2

c. 50^3

(ca) c. Exactly.

un No, his weight is 50^3 times normal. Type in the correct answer.

Problem 8: How much stronger than normal are his legs?

a. 50 times

b. 50^2

c. 50^3

(ca) b. Right you are.

un No, the strength of his legs is proportional to the cross-sectional area, therefore to the second power of length. So strength goes up as the second power of the scaling factor. So to support a weight of 50^3 times, his legs would have to be (the square root of 50^3) or about 350 times as big as that of an ordinary gorilla. His legs would therefore be 7 times as wide as in the movie for the same height. Answer correctly.

Problem 9: Suppose you scale up all the linear dimensions of a steel wire by a factor of three. By what factor does each of the following change?

Volume?

(ca) 27 Right
un Wrong

Mass?

(ca) 27 Right
un Wrong

Surface area?

(ca) 9 Right
un Wrong

Breaking strength?

(ca) 9 Right
un Wrong

Cross-sectional area?

(ca) 9 Right
un Wrong

Heat loss?

(ca) 9 Right
un Wrong

Circumference of cross-section?

(ca) 3 Right
un Wrong

Film113

This film emphasizes two main ideas about crystals. Type in the important points (in brief) from this film, as you remember them.

Problem 1: You probably included these ideas:

1. Crystals are made of many small units, atoms or molecules, all alike.
2. These units are arranged in a regular array. Crystals grow natural plane faces perculiar to various substances. A physicist would describe a solid by saying that:

   a. it is crystalline material.

   b. its atoms are randomly arranged.

   c. its atoms move freely throughout the entire volume of the solid.

(ca) a. Yes, this is what the physicist means by a "solid"

un Mica and quartz are considered "solids" by the physicist; glass is not. Think about this, then type in the correct answer.

un It is the orderly, characteristic arrangement of its atoms, or crystallinity, of a substance which makes it a solid, from a physicist's point of view. Type in the correct answer.

Problem 2: Mr. Holden used pennies and small cubes to represent atoms or molecules, showing the characteristic ________ that can be formed between the natural faces of similar crystals.

(ca) angles Excellent!

un The angles are a convenient way of describing the shape of a crystal. Type in the correct answer. Further evidence for the regular array of atoms in crystals is the fact that cleavage will take place only in certain special directions. What would happen if you attempt to cleave a crystal in some other direction?

Problem 3: The crystal will break up before it will cleave in any direction other than the preferred one (or ones). Suppose that a solution of salol is seeded with alum crystals. What happens?

(ca) nothing Exactly!

un nothing happens.

Solution

If the solution is also seeded with salol crystals, the salol crystals will grow but the alum will be unaffected. This shows that a certain kind of order is characteristic of a particular atom or molecule. Mr. Holden has attempted to show why the study of crystals is so fascinating. If you want to know more, or to have recipes for growing some on your own, see the book "Crystals and Crystal Growing", by Alan Holden and Phyllis Singer, Science Study Series, Doubleday Book Company.

This completes the review of the films shown in class just prior to this hour exam.

Exam1

The 25 questions which follow represent the questions you will probably see on the first hour exam. Try to go through them as rapidly as possible. The presentation of these questions is somewhat different--as explained on page 4 of the supplementary booklet.

Question 1: The order of magnitude of the result of subtracting .0004 from .001 is ____________?

(ca) 10^{-3} correct!

(wa) wrong

Question 2: In best scientific notation, $2.5 \times 10^{-3} - 5 \times 10^{4} =$

(ca) 2×10^{-3} Correct

wa Wrong

Question 3: $$\frac{750 \times 12000}{3.6 \times 10^{5} - .21 \times 10^{6}}$$

(ca) 6×10^{1} Correct

wa Wrong

Question44: Suppose you scale up all the linear dimensions of a steel wire by a factor of three by what factor does each of the following change?

Volume?

(ca) 27 Correct

(wa) Wrong

Question 5: Mass?

(ca) 27 Right

(wa) Wrong

Question 6: Cross sectional area?

(ca) 9 Right

(wa) Wrong

Question 7: Breaking strength?

(ca) 9 Right

(wa) Wrong

Question 8: Surface area?

(ca) 9 Right

(wa) Wrong

Question 9: Heat loss?

(ca) 9 Right

(wa) Wrong

Question 10: Circumference of cross-section?

(ca) 3 Right

(wa) Wrong

Question 11: Is a person's name a function?

(ca) No. Right

(wa) Wrong

Question 12: Is the FSU bus schedule a function?

(ca) yes Right

(wa) Wrong

Question 13: Speed is a scalar quantify. Velocity, because it includes magnitude and direction is a ________?

(ca) vector Right

(wa) Wrong

Question 14: A man takes the following walk; starting from home he travels 10 blocks south, then 12 blocks east, then 2 blocks south, then 7 blocks west, then 8 blocks north, then 5 blocks west, then 2 blocks north. His net displacement at the end of his walk is:

(ca) 2 blocks south Right

(wa) wrong

Question 15: What is the shortest vector that could be represented by the addition or subtraction of two vectors, one of which is 12 cm. long, the other 3 cm.?

(ca) 9 cm. Right

(wa) Wrong

Question 16: The component of acceleration parallel to the velocity changes the velocity's __________ but not its __________.

(ca) magnitude, direction
Right

(wa) Wrong

Question 17: An object starts from rest and moves with an acceleration of 20 meters per second per second north. At the end of 17 seconds its velocity will be ___ ______ ___ ______ _____.

(ca) 340 meters per second north
Right

(wa) Wrong

Question 18: At a temperature of 17 degrees Fahrenheit the average speed of the molecules of a certain gas is found to be 17 centimeters per second. At a temperature of 34 degrees Fahrenheit the average molecular velocity will be ______ than 17 centimeters per second.

(ca) greater Right

(wa) Wrong

Question 19: If the temperature of the gas in a container is kept constant while its volume is decreased, the pressure exerted by the gas will ______________:

(ca) increase Right

(wa) Wrong

Question 20: The limit of resolution of a light microscope is set by the ___________ of light itself.

(ca) wavelength
(cb) nature
Right

(wa) Wrong

Question 21: In the review of scientific notation you found that at times it is necessary to convert numbers to the same power-of-ten in order to add or subtract them. Convert the following numbers as indicated.

$$\frac{4.3 \times 10^2}{10^3}$$

(ca) .43 Right

(wa) Wrong

__Question 22__: $\frac{4.3 \times 10^2}{10^0} =$

(ca) 430 Correct

(wa) Wrong

__Question 23__: $\frac{6.2 \times 10^4}{10^6} =$

(ca) .062 Right

(wa) Wrong

__Question 24__: $\frac{1.3 \times 10^{-5}}{10^{-4}} =$

(ca) .13 Right

(wa) Wrong

__Question 25__: $2.5 \times 10^4 = 250 \times 10^?$

(ca) 2 Right

(wa) Wrong

Of the twenty-five questions on the sample exam you missed ________. You should now review the appropriate concept areas, those areas where you did poorly, before reporting for the hour exam. If you have completed your review here at the CAI Center, enter your comments.

__Gases__

This seven question review section covers the behavior of gases and some basic ideas of atoms and molecules. Read page 7 of your supplementary booklet.

__Problem 1__: In a closed container containing oxygen at a temperature of 27 degrees centigrade and a pressure of 30 newtons per square meter, the average molecular speed is 19 meters per second. If the container is placed in a deep freezer until the average molecular speed is reduced to 15 meters per second, what will happen to the pressure?

a. It will be greater than 30 newtons per square meter.
b. It will stay at 30 newtons per square meter.
c. It will be less than 30 newtons per square meter.

(ca) c. Good. You see that the average molecular speed decreases with temperature, and as a result, the pressure on the walls of the container decreases.

(wa) b,c. No. Remember that the average molecular speed decreases with temperature, and that pressure on the walls of the container will decrease as the molecules of gas no longer hit the walls with as great of force. Now answer the question correctly.

HINT: The temperature of a gas is a measure of its average molecular speed. Also the pressure on the container wall is a function of the velocity of the gas molecules striking it. Thus, when the molecular velocity decreases, the pressure decreases. To simplify, we say that pressure varies directly as temperature. Now pick the correct response.

Problem 2: A gas at 20 degrees centigrade and a pressure of 10 newtons per square meter is contained in a 40 liter volume. If temperature remains constant, and the volume is increased to 80 liters, what will the pressure be?

a. 5 newtons per square meter
b. 10 newtons per square meter
c. 20 newtons per square meter

(ca) a. That's right. If the temperature remains constant, the pressure varies inversely as the volume of an inclosed gas.

(wa) b. No. The pressure will change when the volume is changed if the temperature remains constant. Try to answer correctly now.

(wa) c. Wrong. Remember that pressure varies inversely as volume.

HINT: The pressure of a gas varies inversely as the volume. This means that other things remaining constant, the pressure will go down as the volume goes up and the pressure will go up as the volume goes down.

Problem 3: If the temperature of a gas is increased but its volume is kept constant, the pressure it exerts on the walls of its container will

a. increase
b. decrease
c. remain the same

(ca) a. Very Good.

HINT: Pressure varies directly as temperature when volume is kept constant.

un Wrong. As the temperature of the gas increases, if the volume is kept constant, the average speed of the molecules increases, and more molecules collide with the walls of the container in a given time. Now answer correctly.

Problem 4: If no one had told you how large molecules are, how would you know by direct observation that there are more than 50 molecules of water in a teaspoonful of water?

a. You wouldn't know because water molecules are transparent.

b. Fifty particles that compose a volume of one teaspoonful could easily be felt.

c. Molecules just don't get that big.

(ca) b. That's right.

un No, molecules do get that big. We can think of high polymers such as polyethylene as being a single molecule. In other words, your polyethylene garbage can, in effect, is one big molecule. Now type the correct answer.

Problem 5: Molecules are composed of ______.

(ca) atoms Correct

HINT: Come now, almost everyone knows molecules are composed of ____________.

un Atoms chemically bonded together form molecules.

Problem 6: Brownian motion, which is the result of molecular motion is seen by observing:

a. a steamship in dry dock

b. a man afflicted with St. Vitus dance

c. smoke particles under a microscope

d. a match burning

(ca) c. Good.

(wa) a. No. Brownian motion is observed only in very small particles.

(wa) b. Sorry, St. Vitus dance is a nervous disease called chorea.

(wa) d. No, it is true that a lot of molecular motion is involved when a match burns but just by looking at a match burn you cannot see Brownian motion.

HINT: Brownian motion is observed only in very small particles. Now answer correctly.

<u>Problem 7</u>: A cotton string contains atoms of carbon, hydrogen, and oxygen. This string is said to be

a. a molecule

b. a collection of molecules

c. a crystal

(ca) b. Good.

(wa) a. Wrong. Cotton is a fiber made of cellulose molecules.

(wa) c. No. A cotton string is not a crystal. Have you ever seen some one's cotton shirt cleave along characteristic planes? Now answer correctly.

HINT: Have you ever heard of anyone growing a cotton crystal?

This is the end of the review of gases and molecules. You may go on to review other sections or you may take the sample exam (see the appropriate instructions in your booklet).

<u>Vectors</u>

VECTORS AND THEIR USE

<u>Question 1</u>: An aircraft flys North at 100 mph. There is a cross wind blowing East at a speed of 50 mph. In what direction and at what speed will the plane end up flying. (Let 1/4 inch = 25 mph.)

a. Northeast at 90 mph.

b. North-northeast at 112 mph

c. North-northeast at 110 mph

d. I do not understand.

(ca) b. Yes, you're right. We know from the laws of vector addition, that

1. The speed of the aircraft must increase.
2. The direction of the aircraft is changed <u>in the direction</u> of the wind.

(wa) a. No, the speed is wrong. We know from the laws of vector addition that the speed of the plane <u>must</u> increase. You're close to the correct direction. Re-construct the vector diagram and try the problem again.

(wa) c. You are exactly right as far as the direction is concerned. However, the accuracy to which you measured the speed is not good enough. Re-draw the vector diagram and try the problem again.

(wa) d. Since you do not understand the problem, we suggest that you read the appropriate section of your text again. Also read the VECTORS section of our booklet again paying particular attention to Figure 3. When you are ready to proceed, simply type in the letter associated with the correct answer. If and <u>only</u> when you still fail to understand the answer, you should call the proctor and request additional help.

<u>Question 2</u>: Now for a more complex problem. Suppose, starting at Westcott building, you take the following walk: You walk 1 block north, 1 block east, 2 blocks north, 2 blocks west, 1 block south, 2 blocks east, 2 blocks south and 1/2 block west. Your net displacement at the end of your trip is __ ______ ______.

(ca) 1/2 block east. Good. And in case you're interested you are in front of the Zeta house--halfway down the hill in front of Westcott.

(wa) 1/2 block west. No. You have the right length but the wrong <u>direction</u>. <u>Remember</u>: For this type of problem, the answer is the <u>vector that will make the trip more direct</u>. In this case, the answer vector will also make the trip shorter. Now, type in the correct answer.

un You should express your answer in both units of distance (blocks) and (direction). (north, south, etc). Type it as X blocks.

<u>Question 3</u>: Here is a question you just <u>may</u> find on the exam: A vector 4 feet long could be added to a vector 3 feet long to produce a vector whose length is:

a. 8 feet

b. .5 feet

c. 5 feet

(ca) c. Good.

(wa) a. No. With only two vectors -- one 4 feet long and the other only 3 feet long -- there is no possible way we can add them and get a resultant vector longer than the sum of the two original vectors (7 feet in this case). Rework the problem and select the correct answer.

HINT: Find both the longest and shortest possible resultants of the vectors.

(wa) b. No. There is no possible way we can add a vector having a four feet length to another vector three feet in length and achieve a resultant shorter than the difference in the length of the two vectors. Rework the problem and select the correct answer.

un You may add the vectors choosing any direction you wish. When you have an answer, type the appropriate letter.

<u>Question 4</u>: A man takes the following trip: starting from home he travels 10 blocks south, then 12 blocks east, then 2 blocks south, then 7 blocks west, then 8 blocks north, then 5 blocks west, then 4 blocks north. His net displacement at the end of this trip is:

a. 48 blocks

b. 12 blocks south

c. zero

(ca) c. You're right, he has returned to his home.

(wa) a. No, remember that displacement is a vector and that when adding vectors you must consider their direction.

(wa) b. No, your arithmetic seems to be incorrect. Try again.

HINT: Add the blocks and directions as vectors.

<u>Question 5</u>: A fisherman in Key West knows that to get to the best spot to catch sailfish, he must go 4 miles south of the harbor and then go 3 miles west. How much distance can he avoid traveling by sailing directly from the harbor to his fishing spot?

a. 2 miles

b. 5 miles

c. 3 miles

(ca) a. Good. The straight line distance to the fishing spot is 5 miles, which is 2 miles less than the 3 and 4 miles he traveled to get there by going 4 miles south and 3 miles west.

(wa) b. No. The straight line distance from the fishing spot to the harbor is 5 miles. Now find how many miles he can save and answer the question correctly.

HINT: Draw the triangle and measure the distances involved. How many miles can he save?

Question 6: A pilot making a reconnaissance flight from the Saigon airport flies due north for 50 miles, west for 100 miles, south for 75 miles. He turned east and flew at 80 miles per hour for one hour and 15 minutes. Then he ran out of gas and had to land. How far and in what direction would he have to walk to get back to the Saigon airport?

a. 20 miles east

c. 25 miles north

b. He landed at the Saigon airport?

(ca) c. That's right.

(wa) a,b. No. Go through the problem carefully again and draw his path to scale if necessary, then type in the right answer.

HINT: Add the distances and directions flown as vectors.

un No. The pilot flew north for 50 miles, and south for 75, which leaves him 25 miles south of Saigon. He also flew west for 100 miles and east at 80 miles per hour for one hour and 15 minutes. At that time and velocity, he flew 100 miles east, cancelling his western flight. Therefore, his net displacement is 25 miles south of Saigon. Go through the problem again for yourself and answer it correctly.

Question 7: A vector whose magnitude is 5 could be the sum of a vector whose magnitude is

a. 10 and one whose magnitude is 3
b. 3 and one whose magnitude is 5
c. 17 and one whose magnitude is 10

(ca) b. Right, and in case you are interested, the vectors are at an angle of 72 degrees to one another.

(wa) a,c. No, if the two vectors were pointing opposite to one another the smallest vector they could form would have a magnitude of 7. Try again.

HINT: Try adding the vectors to get the smallest possible resultant.

Question 8: Which of the following is a vector?

a. finite rotations

b. speed

c. displacement

(ca) c. Right you are, very good.

(wa) a. No, in adding finite rotations the resultant depends on the order in which they are added. This is not true of a vector.

(wa) b. No, speed is a scalar, velocity is a vector.

HINT: Finite rotations count the number of rotations, speed gives the distance traveled per unit time but not direction, and displacement gives a distance and a direction.

Question 9: A vector 13 feet long is resolved into Cartesian components. If the x-component is 12 feet long, the y-component could be

a. 1 foot long

b. zero

c. 5 feet long

(ca) c. Good.

HINT: Draw a scale diagram.

(wa) a. No. Remember that the magnitude of a vector is the square root of the sum of the squares of the cartesian components.

(wa) b. No. An x component 12 feet long added to a y component of zero feet would give a resultant of 12 feet. Try again.

This completes the review of vectors. You should continue reviewing or take the sample exam. Follow the directions given in the supplementary booklet.

Review22

Problem 1: Type the names of the four fundamental units of measure. (Use small letter with spaces between the words.)

(ca) force mass length time
Good.

(wa) force mass length

un I guess you couldn't list them after all.

Problem 2: Convert 25.4 km to inches, using the following facts:

1 inch = 2.54 cm and 1 km = 100,000 cm.

a. 1,000,000 in.

b. 100,000 in.

c. 254,000 in.

d. 2,540,000 in.

(ca) a. Very good.

(wa) bcd. Incorrect. The rationale for this problem is that there is 100,000 cm in a km so to find how many cm in 25.4 km you multiply. Then because there are 2.54 cm in one inch you divide by 2.54 to see how many inches there are in 2,540,000 cm. NOTE: The km and cm units cancel.

Problem 3: If the acceleration of gravity is G = 9.8 meters/sec^2 what is it in miles/hr. Use 1 mile (mi) = 5280 ft. and 1 meter = 3.2 feet. Don't forget there are 3600 seconds in 1 hour.

a. 5280 mi/hr^2

b. 9.8×3600^2

c. $9.8 \times 3.2 \times 3600^2$ mi/hr^2

d. 11,186 mi/hr^2

(ca) c. Very well done.

(wa) abd. Incorrect.

Problem 4: Now that we've pointed out the four fundamental units (mass, length, time, and force) and that units of measure can be manipulated and treated as algebraic quantities within an equation, we want to point out that you may predict, with reasonable accuracy, what an equation should look like just by knowing what answer you wish to find. For example, suppose you know that a friend arrived in Tallahassee after traveling for two hours (let's call this time t) at an average speed of 55 miles an hour (let's note the speed as v). You can write the equation which will tell you the distance he traveled just by knowing that distances such as this are ordinarily expressed in miles. Can you write the equation that will help us calculate this distance? (For convenience, let's refer to the distance as d.)

a. t/v = d

b. d/v = t

c. v = t/c

d. d/t = v

e. $d = v/t$ h. $vd = t$

f. $td = v$ i. $d = tv$

g. $t = v/d$ j. I don't know.

(ca) i. Good. You can tell that this rather simple, example equation is true just by looking at it. That is, we did want to know how far he traveled and the units of the answer are in miles so we can be reasonably sure this is the correct equation. However, if it were more complex, the next step to testing the assumption that this was the correct equation would be to "Plug in" the numbers and calculate a numeric answer. If this answer seemed to be exorbitant we would have reason to suspect the equation or our calculations. (By exorbitant we mean, would you believe that the trip above covered two feet? We hope not.)

(wa) j. Sure you do. To get, as a result, distance (miles). Now that you've thought about it for awhile, select the appropriate equation. (Just type the associated letter.)

un Consider that algebraic operation which will allow a combination of speed and time to get distance.

<u>Refract</u>

The eight problems which follow will help you understand the phenomenon of light known as refraction.

<u>Problem 1</u>: When we say light is refracted we mean that

a. light bends around the corners of a small slit
b. light bounces off of a surface
c. light is "bent" when passing from one medium into a different medium

(ca) c. Good.

(wa) a. No, this describes the phenomenon known as diffraction.

(wa) b. Wrong, This describes reflection.

HINT: Remember what happens when a light beam enters water.

<u>Problem 2</u>: When a beam of light enters a tank of water:

a. the normal to the surface is not in the same plane as the refracted and incident rays

b. the refracted ray is not in the same plane as the normal to the surface and the incident ray

c. the incident ray, the refracted ray and the normal to the surface are all in the same plane

(ca) c. Correct.

(wa) a,b. Wrong. Read page 211 in Physics 1st edition of the Physical Science Study Committee.

HINT: If you really need a hint for this question, call the proctor.

Problem 3: In figure 2, page 15 of the supplementary booklet which angle is the angle of incidence? (Type the letter of the angle.)

(ca) b. Good.

un The angle of incidence is formed by the incident beam and the normal to the surface. Now answer the question correctly.

Problem 4: In figure 2, page 15 of the supplementary booklet, which angle is the angle of refraction? (Type the letter of the angle.)

(ca) d. Good.

un The angle of refraction is formed by the refracted beam and the normal to the surface. Now answer correctly.

Problem 5: When light is refracted upon entering a material from air, one of the following is true. Which one?

a. sin i = sin r
b. the ratio of sin i/sin r is a constant
c. the index of refraction is equal to sin r
d. the speed of light doesn't change

(ca) b. Good thinking.

(wa) a. You may be confusing this with the laws of reflection; however, there is a special case, where sin i = sin r when the material's index of refraction is the same as air's. But if this were true then refraction would not occur.

(wa) c. Wrong. Recall Snell's law and answer correctly.

(wa) d. Wrong. The reason light is refracted is that its speed has changed. Now answer correctly.

HINT: Recall Snell's law.

Problem 6: Now, what is the ratio sin i/sin r called? (Type in your answer.)

(ca) index of refraction
refraction index
index refraction
That's right. Let's continue.

(wa) Snell's index. True, at least in the sense that the index was formulated by Snell but it does not normally carry his name. It is the index of something.

(wa) refraction. That's only part of the correct answer. When we speak of "refraction", we normally speak of the physical phenomenon itself. This ratio is the ________ ___ refraction.

(wa) index of. Now you're getting it. Type the complete term.

(wa) index of refractn. I think you're right but your spelling of the term is confusing. Please type it correctly.

un This ratio is known as the index of ________.

un This ratio sin i/sin r is called the index of refraction. Now type in the correct answer.

Problem 7: Remember that the index of refraction of a substance is expressed by: sin i/sin r = index of refraction. If the index of refraction for a diamond were 2.5 and a ray of light strikes a facet (or face) of this diamond with a 30° angle of incidence, what is the value of sin r? (sin 30° = .50)

(ca) .20 or .2 or 0.2 or 2.0 X 1088^{-1} or 2 X 1088^{-1}
Excellent. In case you're interested, the angle r = 11.3°.

un We're not trying to find the angle r, but only the value of sin r. Simply substitute values in the relationship and solve for sin r. Now type your answer.

un Follow this: index of refraction (sin i/sin r). We're given: i = 30°. Hence: sin i = sin 30° = .5. We're also given: index of refraction = 2.5 substituting 2.5 = .5/sin r sin r - .5/2.5. Now what is the value of sin r? (Type in your answer)

un sin r = 0.2. Type that value now.

Problem 8: If the speed of light in air is 3×10^8 m/sec, what would be the speed of light passing through a diamond which has an index of refraction of 2.4?

(ca) 1.25 X 10888 m/s   Excellent.   Very good.

HINT: Remember that the index of refraction is the ratio of the speed of light in one medium to the speed of light in another medium.

un The way to solve this is: $2.4 = \frac{\text{velocity of light in air}}{\text{velocity of light in diamond}}$

$2.4 = 3 \times 10^8$ m/sec

$V = 3 \times 10^8$ m/sec

$V = 1.25 \times 10^8$ m/sec

Please type the speed of light in the diamond now.

This completes the review of refraction. Select the next section you would like to review from page 13 of the supplementary booklet.

Exam2

Please read page 16 of the supplementary booklet for instructions regarding this section.

Exam2A

Problem 1: Can light be deflected from a straight line path? (One word answer, please.)

(ca) Yes. Right.

(wa) Wrong.

Problem 2: Does the wave model of light satisfactorily predict the behavior of light as you have learned it for this course? (One word answer, please.)

(ca) Yes. Right.

(wa) Wrong.

Problem 3: A beam of light strikes a plane mirror with an angle of incidence of 40°. What is the angle of reflection?

(ca) 40° or 40 degrees or forty degrees
Right.

(wa) 40 or forty
Wrong. That's the right numerical answer, but you're counted wrong because you left off the units. The correct answer was 40° or 40 degrees.

Problem 4: The image distance for an image formed by a plane mirror is found to be 40 cm. The distance from the object to the mirror must be ________?

(ca) 40 cm or 40 centimeters or forty cm or forty centimeters or 40 cm.
Right.

(wa) 40
forty
Wrong. That's the right numerical answer, but you're counted wrong because you left off the units.

Problem 5: The image in question 4 is what kind of image?

(ca) virtual Right.

(wa) Wrong.

Problem 6: A ray of yellow light goes from air to water with an angle of incidence of 35°. What can you say about the size of the angle of refraction with regard to the size of the angle of incidence?

(ca) smaller or less than Right.

(wa) Wrong.

Problem 7: In order to explain why a light ray bends toward the normal when passing from air to water with the wave model of light, it is necessary to assume that light moves ________ in water than in air.

(ca) slower Right.

(wa) Wrong.

Problem 8: Using the particle model of light to explain the phenomenon in question 7, we must assume that the light particles move ________ in water than in air. (One work answer, please.)

(ca) faster Right.

(wa) Wrong.

Problem 9: A water wave whose amplitude (maximum displacement of the medium either above or below equilibrium) is 1/2 meter crosses another whose amplitude is 1/4 meter. If the two waves are in phase, the net amplitude will be __________.

(ca) 3/4 meter
3/4 m
.75 m
.75 meters
0.75 m
0.75 meters
7.5×10^{-1} m
7.5×10^{-1} meters
3/4 meters
7.5×10^{-1} meter
.75 meter
0.75 meter
Right.

(wa) .75
3/4
0.75
7.5×10^{-1}
Wrong. That's the right numerical answer, but you're counted wrong because you left off the units.

Problem 10: If the two waves in the previous question were out of phase, the net amplitude would be:

(ca) 1/4 meter
1/4 m
1/4 meters
.25 m
.25 meters
.25 meter
0.25 m
0.25 meters
0.25 meter
2.5×10^{-1} m
2.5×10^{-1} meters
2.5×10^{-1} meter
Right.

(wa) 1/4
.25
0.25
2.5×10^{-1}
Wrong. That's the right numerical answer, but you're counted wrong because you left off the units.

Problem 11: The dark bands seen in diffraction patterns are the result of __________ interference.

(ca) destructive Right.

(wa) Wrong.

Problem 12: When a transverse wave pulse passes from one medium to a more dense one, its speed will __________.

(ca) decrease Right.
less

(wa) Wrong.

Problem 13: sin i/sin r is a constant for a particular substance, this constant is called the _____ ___ _________?

(ca) index of refraction
refractive index
Right.

(wa) Wrong.

Problem 14: A ray of light is incident on a concave spherical mirror with an angle of incidence of 20^{o}. What is the angle of refraction?

(ca) 20^{o}
twenty degrees
twenty^{o}
Right

(wa) 20
twenty
Wrong

Problem 15: A ray of light is incident on the surface of a pond at an angle of 20^{o}. The incident and reflected rays lie in the same plane. What angle does the normal to the surface of the pond form with the plane of the incident and reflected rays?

(ca) 0^{o}
zero degrees
zero^{o}
0 degrees
Right

(wa) Wrong.

Problem 16: Does the wave model of light adequately explain the phenomenon of diffraction?

(ca) yes Right.

(wa) Wrong.

Problem 17: A piece of glass is treated so that it will be non-reflecting for red light. Will it also be non-reflecting for blue light?

(ca) no Right.

(wa) Wrong.

Problem 18: If the piece of glass were treated to be non-reflective for blue light, would it also be non-reflecting for red light?

(ca) no Right.

(wa) Wrong.

Problem 19: Of the ways in which light can be bent, the particle model cannot explain one of them. Which one is it?

(ca) diffraction Right.

(wa) Wrong.

Problem 20: A wave with a period of 10 seconds and a wavelength of 10 meters is moving through a uniform medium. What is this wave's speed?

(ca) 1 m/s
1 meter per second
one meter per second
one m/s
Right

(wa) Wrong.

Exam2B

Problem 1: Which of the following will not deflect light from a straight line path?

a. a mirror
b. a diamond
c. The Pacific Ocean.
d. The earth's magnetic field.

(ca) d Right.

(wa) Wrong.

Problem 2: Reflection, scattering, refraction, and diffraction can be explained by

a. Newton's particle model of light
b. the wave model of light
c. both Newton's model and the wave model

(ca) b. Right.

(wa) Wrong.

(wa) b. No, your arithmetic seems to be incorrect. Try again.

HINT: Add the blocks and directions as vectors.

Question 5: A fisherman in Key West knows that to get to the best spot to catch sailfish, he must go 4 miles south of the harbor and then go 3 miles west. How much distance can he avoid traveling by sailing directly from the harbor to his fishing spot?

a. 2 miles
c. 3 miles
b. 5 miles

(ca) a. Good. The straight line distance to the fishing spot is 5 miles, which is 2 miles less than the 3 and 4 miles he traveled to get there by going 4 miles south and 3 miles west.

Problem 3: A ray of light makes an angle of 50° with the surface of a mirror that it is incident on. What is the angle of refraction?

a. 50°
c. 0°
b. 24^0
d. 40°

(ca) d. Right.

(wa) Wrong

Problem 4: The image distance for an image formed by a plane mirror is found to be 40 cm. What are the dimensions of the image?

a. 40 cm
c. the same as the object's dimensions
b. 80 cm
d. one fortieth of the object's dimensions

(ca) c. Right.

(wa) Wrong.

Problem 5: The image in question 4, is

a. a real image
c. an inverted image
b. a real, inverted image
d. a virtual image

(ca) d. Right.

(wa) Wrong.

Problem 6: A ray of yellow light goes from air to water with an angle of incidence of 35°. The angle of refraction is

a. greater than 35°
c. less than 35°
b. 35°
d. 0°

(ca) c. Right.

(wa) Wrong.

Problem 7: Using the wave model of light, to explain why a light ray bends toward the normal when passing from air to water, it is necessary to assume that

a. light travels faster in water than in air
b. light travels slower in water than in air
c. light travels at the same speed in both water and air.

(ca) b. Right.

(wa) Wrong.

Problem 8: Using the particle model of light to explain why light bends toward the normal when passing from air to water, it is necessary to assume that

a. light travels faster in water than in air
b. light travels slower in water than in air
c. light travels the same speed in both water and air.

(ca) a. Right.

(wa) Wrong.

Problem 9: A water wave whose amplitude (maximum displacement of the medium either above or below the equilibrium) is 1/2 meter crosses another whose amplitude is 1/4 meter, if the two waves are in phase, the net amplitude is

a. 1/4 meter
b. 6 meters
c. 3/4 meter
d. zero

(ca) c. Right.

(wa) Wrong.

Problem 10: If the two waves in the previous question were out of phase, the net amplitude could be

a. 1/4 meter
b. 6 meters
c. 3/4 meter
d. zero

(ca) a. Right.

(wa) Wrong.

Problem 11: The dark bands seen in diffraction patterns are the result of

a. constructive interference

b. reinforcement

c. destructive interference

d. specular reflection

(ca) c. Right.

(wa) Wrong.

Problem 12: When a transverse wave pulse passes from one medium to a more dense one

a. its speed will decrease

b. its speed will increase

c. its period will increase

d. its frequency will decrease

(ca) a. Right

(wa) Wrong.

Problem 13: The index of refraction for a particular medium that is contrasted to another medium may be defined as

a. sin i X sin r

b. sin r/sin i

c. sin i/sin r

d. sin i X sin i/sin r

(ca) c. Right.

(wa) Wrong.

Problem 14: A ray of light is incident on a concave spherical mirror with an angle of incidence of 20°, what is the angle of reflection?

a. 20°

b. 10°

c. 0°

d. cannot tell, because the mirror is not plane.

(ca) a. Right.

(wa) Wrong.

Problem 15: A ray of light is incident on the surface of a pond at an angle of 20°. The incident and reflected rays lie in the same plane. What angle does the normal to the surface of the pond form with the plane of the indicent and reflected rays?

a. 20° c. 0°

b. 70° d. 90°

(ca) c. Right.

(wa) Wrong.

Problem 16: Which of the following can the wave model of light explain and the particle model not explain?

a. reflection c. scattering

b. refraction d. diffraction

(ca) d. Right.

(wa) Wrong.

Problem 17: A piece of glass is treated so that it will be non-reflecting for red light. Then

a. the glass will not reflect blue light
b. the glass will not reflect yellow light
c. the glass will reflect blue light.

(ca) c. Right.

(wa) Wrong.

Problem 18: If a piece of glass were treated to be non-reflecting for blue light, then

a. the glass will reflect red light
b. the glass will reflect yellow light
c. the glass will not reflect red light.

(ca) c. Right.

(wa) Wrong.

Problem 19: The particle model of light cannot explain

a. angle of incidence is equal to angle of reflection
b. sin i/sin r = index of refraction
c. interference patterns.

(ca) c. Right.

(wa) Wrong.

Problem 20: A wave with a period of 10 seconds and a wave length of 10 meters is moving through a uniform medium. What is the wave's speed?

a. 10 m/sec
b. 100 m/sec
c. 1 m/sec
d. 0.1 m/sec

(ca) c. Right.

(wa) Wrong.

You have now completed the multiple choice exam.

Reflect

The following seven problems discuss the phenomenon of light reflection.

Problem 1: When the eye sees light rays which appear to emerge from an object as far behind a plane mirror as the actual object is in front of the mirror; then the image is known as

a. a perverted image
c. an inverted image

b. a virtual image

(ca) b. Correct.

(wa) a. No, when an image is perverted the right and left sides are interchanged.

(wa) c. No, when an image is inverted it is upside-down compared to the actual object.

Problem 2: In Figure 1, page 15 of the supplementary booklet, which angle is the angle of incidence? (Type the latter of the angle.)

(ca) c. Correct

un The angle of incidence is formed by the incident beam and the normal to the surface. Try again.

Problem 3: What is the angle of reflection in diagram 1, page 15 of the supplementary booklet? (Type the letter of the angle.)

(ca) b. Correct.

un The angle of reflection is formed by the reflected beam and the normal to the surface. Try again.

Problem 4: An object 4 cm tall is placed 12 cm in front of a plane mirror. The virtual image you see is

a. 4 cm tall and 12 cm behind the mirror
b. 4 cm behind the mirror and less than 4 cm tall
c. 12 cm behind the mirror and less than 4 cm tall
c. 6 cm behind the mirror and 2 cm tall.

(ca) a. Good.

(wa) c. No. You're right about the distance behind the mirror but the height of the image is not less than 4 cm. Now answer correctly.

(wa) b. No. Try tracing the paths of a few light rays. (This is called drawing a ray diagram.) The image will be the same size as the object but will be more than 4 cm behind the mirror. Answer again.

(wa) d. Wrong. The image will be more than 2 cm tall and more than 6 cm behind the mirror. Try again.

HINT: Remember that a virtual image from a plane mirror appears as far behind the mirror as the object is in front of it.

Problem 5: When you glare at yourself in the mirror in the morning, the image you see is:

a. virtual
b. real
c. inverted
d. ugly

(ca) a. That's right. Aren't you glad that it's not real?

(wa) b. No. The image you see is not real because it cannot be focused. The fact that the image appears to be behind the mirror should tell what it is. Try again.

(wa) c. No. The image you see has the hair on top, not on the bottom, so it is not inverted.

(wa) d. Speak for yourself. Now get serious and type the letter of the correct answer.

Problem 6: The reason you cannot read what is printed on a page, when the printing is reflected from a plane mirror, is:

a. the image is real
b. the image is virtual and inverted
c. the image is virtual and has right and left reversed
d. the image is real and has right and left reversed.

(ca) c. Good.

(wa) a. Wrong. The image cannot be focused and lies behind the mirror. Therefore, it is not real. Try again.

(wa) b. You are correct in thinking that the image is virtual; however, the image is not inverted (up-side down). Now answer correctly.

(wa) d. You are partially correct. The right and left sides are reversed, but the image formed by a plane mirror is not a real image. Now answer correctly.

HINT: Imagine you are looking at your image in a mirror and you wiggle your right ear, what ear will your image wiggle back at you? Now answer the question correctly.

Problem 7: The image formed by a parabolic mirror of an object beyond the focal point of the mirror is.

a. real and inverted
b. real and upright
c. real and virtual
d. virtual and inverted

(ca) a. Very good.

(wa) b. You are partially correct. The image is real but it is not upright. Draw a ray diagram and then answer correctly.

(wa) c. Wrong. Think for a moment about a real image. You know that a real image can be focused on a white card. A virtual image cannot be focused. Now how can the same image be both real and virtual? Draw a ray diagram and then answer correctly.

(wa) d. No. The image will be inverted, but a parabolic mirror can be used to focus an image. What do these facts tell you about the type of image? Try again.

HINT: Draw the ray diagram.

Waveprop

The four questions which follow are designed to help you review wave properties.

Problem 1: A wave is a disturbance which when through a medium

a. Does not upset the equilibrium of the material in the medium
b. Does not cause an appreciable, net motion of the medium in the medium in the direction of travel of the disturbance
c. Usually has no definite speed associated with it
d. Transmits no energy from one point in the medium to another point in the medium.

(ca) b. You are correct.

(wa) a. Wrong. A wave traveling along a spring distorts the spring as it travels. Now try again.

(wa) c. Wrong. A wave is characterized by three things, a period, a frequency and a wavelength. The period, T, is the time it takes a complete wavelength, L, to pass a given point. From this you can see that a wave has a definite speed associated with it. Now answer correctly.

(wa) d. Wrong. Waves transmit energy. This is exemplified by the terrible power of a sunami (a great sea wave produced by submarine earth movement or volcanic eruption). Now answer correctly.

HINT: No hint available here. If you don't know the definition and properties of waves you should read your text again.

Problem 2: Suppose we generate periodic waves at a frequency of 5 waves per second and the distance between the crests is 3 meters.

a. 15 meters/sec

b. 1.33 meters/sec

c. 0.6 meters/sec

(ca) a. Very good, you remembered that $v = fL$

(wa) b,c. No. Remember that ($v = fL$), velocity equals frequency times the wavelength.

HINT: Remember that ($v = fL$), velocity equals frequency times the wavelength.

Problem 3: A train of periodic waves with a period of 3 seconds travels in a medium in which its wavelength is 18 centimeters. Its speed in this medium is ________?

(ca) 6 cm/sec
6.0 cm/sec
six cm/sec
six cm per sec
6 cm per sec
6.0 cm per sec
6 centimeters per second
6.0 centimeters per second
six centimeters per second
6 centimeters/sec
6.0 centimeters/second
6.0 centimeters/sec
6 centimeters/sec
six centimeters/sec

Good.

(wa) 6
6.0
six

un Right number, but six what? Think of the units of the answer for a clue to the solution to the problem. To work the problem, divide the period into the wavelength to get _______ cm/sec.

Problem 4: The wave train in the above question enters a second medium in which its speed is 4 cm/sec. Its wavelength in the second medium is

a. less than 18 cm
b. equal to 18 cm
c. greater than 18 cm

(ca) a. Right, you found the wave length by L/T = speed
1/3 sec = 4 cm/sec L = 12 cm

(wa) b. Wrong. The wavelength must change when entering the second medium because the period remains the same.

(wa) c. Wrong. Use the relationship L X f = speed to solve this problem. (Remember F = 1/T). Try again.

HINT: Use the relationship L X F = speed. (Remember F = 1/T.)

Wavbehav

The next eight examples have been created to help you master how waves interact and apply to the study of light.

Problem 1: When two light waves meeting in a medium are "in phase",

a. they cancel each other out
b. their wave lengths are reciprocals of each other
c. they interfere constructively
d. they do not interfere.

(ca) c. Correct. This is called constructive interference or reinforcement.

(wa) a. No. If two light waves are in phase, they do the opposite of canceling each other out. Try again.

(wa) b. Wrong. You may be confusing this question with the relationship T = 1/f. Remember what "in phase" means and answer by typing in A, B, C, or D.

(wa) d. Wrong. When waves are in phase they reinforce one another. Now answer by typing the correct letter.

HINT: Diffraction patterns are evidence for light being in and out of phase in certain areas.

Problem 2: Reflection, refraction and diffraction

a. can all be explained by the particle model of light
b. can all be explained by the wave model of light
c. are all independent of wavelength
d. do not result in the bending of light

(ca) b. Correct.

(wa) a. No, the particle model of light cannot easily explain diffraction.

(wa) c. Wrong. Remember that refracted blue light bends sharper than refracted red light. This is the principle of the spectrum produced by a prism from white light. Now answer correctly.

(wa) d. Absolutely wrong. Reflection, refraction, and diffraction are all examples of light bending. Now look over the choices and answer correctly.

HINT: One of the light models cannot explain diffraction.

Problem 3: Diffraction

a. is related to interference
c. results in sharp shadows of small objects
b. of light can only be observed with very wide slits

(ca) a. Correct. Constructive and destructive interference produce the light and dark areas which characterize diffraction.

(wa) b. Wrong. Let's try a short experiment. Close one eye and focus the other at a light source. Now arrange your thumb and forefinger so that you can see the light source between the two. Continue looking at the light source and bring your fingers together and observe what happens.

(wa) c. No. Diffraction does not cause shadows of small objects to be sharp. Diffraction as bands of light and dark areas when light shines through small openings.

HINT: . No. Diffraction is seen as light and dark areas when light goes through very small openings. Think about this and answer the question by typing A, B, C, or D.

D

Problem 4: When light passes from air into the Hope diamond, its speed

a. Increases

b. Decreases

c. Remains the same

d. The speed of light is infinite so we cannot say anything about it.

(ca) b. Right.

(wa) a. Wrong. This is where the particle model has trouble, the speed of light does not increase when going from one medium to a denser medium. Now answer correctly.

(wa) c. No. Refraction is caused by a change in speed of light. Now answer correctly.

(wa) d. No. Remember that the speed of light is very high, about 670 million miles per hour, but it is not infinite. Now answer correctly.

HINT: The refractive index of air is close to one, and the refractive index of diamond is about 2.42.

Problem 5: Using the wave model of light, which way would you predict the refracted beam would bend when the light goes from glass to vacuum?

a. Toward the normal

b. Away from the normal

c. Out of the plane in which the normal and incident beams lie.

(ca) b. Good. The beam bends away from the normal when the beam goes from a dense medium to a less dense medium.

(wa) a. Wrong. Remember that the beam is passing from a dense medium to a less dense medium. Now answer by typing the correct letter.

(wa) c. Wrong. Remember the rules of refraction. The incident beam, refracted beam and the normal to the surface all lie in the same plane. Now answer correctly.

HINT: Light bends toward the normal when passing from vacuum to glass. Now what will it do when passing from glass to vacuum?

<u>Problem 6</u>: When periodic waves pass from one medium into a denser one, their

a. frequency decreases

b. speed decreases

c. wavelength does not change

(ca) b. Right, since the frequency remains the same and the wavelength decreases, the speed decreases.

(wa) a. No, the frequency remains the same. Try again.

(wa) c. Wrong, the wavelength actually decreases as the wave passes into a denser medium. Now answer correctly.

HINT: Remember what happens to the speed of light when it enters water from air.

<u>Problem 7</u>: According to the superposition principle, when two sound waves of different sizes cross in air

a. they do not interfer
b. the net displacement of the air is the sum of the individual displacements
c. the larger wave will absorb the smaller one.

(ca) b. Excellent, let's continue.

(wa) a. No. Since both waves displace the air, they are bound to interfere with one another. Try again.

(wa) c. No. The displacement of <u>both</u> waves, added together, determines the <u>net displacement</u>. That is, the effect of the smaller wave is not lost or neglected.

HINT: The net displacement is the sum of the two waves displacements.

Problem 8: If two equal wave trains are out of phase when they cross in a medium, the displacement of the medium at the point of crossing will be

a. one-half of what it would be for one of them
b. zero
c. twice what it would be for one of them
d. four times what it would be for one of them.

(ca) b. That's right. This is called destructive interference.

(wa) a. Wrong. Remember that we are considering two equal wave trains which are out of phase.

(wa) c,d. Wrong. Remember that the wave trains are out of phase not in phase. Now answer correctly.

HINT: Recall a diffraction pattern, the dark bands are results of out of phase, wave trains crossing.

Ltpart

The next three questions will help you review the particle model of light.

Problem 1: The particle model of light assumes that light particles

a. are too large to be deflected by air.
b. travel so fast we don't notice gravitational bending of their paths.
c. are reflected from both hard and soft surfaces.

(ca) b. Very good.

(wa) a. No, just the opposite is true. The particle model of light assumes that light particles are extremely small. Knowing this, answer the question correctly.

(wa) c. No, the particle model of light assumes that light particles are reflected only from hard surfaces. Try again.

Problem 2: Difficulties were encountered with the particle model of light when it was discovered that

a. light exerts a pressure
b. light travels faster in a vacuum than any other medium
c. light can be bent at right angles.

(ca) b. Right.

(wa) a. Wrong. The fact that light exerts a pressure is compatible with the idea that light is composed of small particles traveling at high speed. Try again.

(wa) c. Wrong. Particles can be bounced off of smooth surfaces much as a tennis ball would bounce. Now answer correctly.

HINT: Remember that in refraction, light bends toward the normal when entering water from air. If light were composed of particles, this would mean that they would be going faster in the air.

<u>Problem 3</u>: The particle model of light cannot explain

a. reflection
c. diffraction

b. intensity of sources of light
c. straight line light paths.

(ca) c. Excellent.

(wa) a. Wrong. Reflection can be explained in the particle model of light. The angle of incidence is equal to the angle of reflection for a steel ball hitting a steel plate at high speed. (See page 238 <u>Physics</u> <u>First Edition</u> by Physical Science Study Committee.)

(wa) b. Wrong. Source strength can be explained by the particle model in terms of how many particles are emmitted per second. Now answer correctly.

(wa) d. Wrong. The particle model of light assumes the particles to be traveling so fast that any bending due to gravity could not be seen to any practical extent. Now answer correctly.

HINT: Would a stream of particles bend going through a slit?

<u>Film203</u>

The following four items will help you to recall the concepts of the PSSC film covering the measurement of the speed of light.

<u>Problem 1</u>: Here's an easy question. Which statement is true?

a. The speed of light, being infinite, cannot be measured.
b. The speed of light can be measured.

(ca) b. Right. We're off to a good start.

(wa) a. Then what was Mr. Siebert doing with all those mirrors and electronic equipment on the football field? Try again.

<u>Problem 2</u>: The second experiment in the film was a measurement of a difference. That is, the time difference along two paths (one through air, one through water) was made to be zero by adjusting the length of one of the paths. This measurement has important implications for the particle model of light. Remember, for the particle model to provide an explanation for Snell's law, it i is necessary to assume that

a. Light travels faster in water than in air.
b. Light travels faster in air than in water.

(ca) a. Correct.

(wa) b. Wrong.

HINT: To explain the fact that a light ray bends <u>toward</u> the normal as it enters a refraction medium like water, the particle model required that the speed increase. Now type in a or b.

<u>Problem 3</u>: In the film, we saw that the speed of light in water is

a. greater than in air
b. less than in air
c. the same as in air

(ca) b. You remembered correctly.

(wa) a,c. No, remember the air path had to be made longer than the water path. Therefore, the speed in water must be what compared to air, if the time to traverse the two paths is the same? Try again.

HINT: Remember that the air path had to be longer than the water path.

<u>Problem 4</u>: Since the speed of light in water is less, NOT greater, than in air, the particle model of light

a. must be discarded
b. is proved correct
c. must be modified

(ca) c. Very good. We will take this up again later in the course, after you've learned more about mechanics, and how particles behave.

(wa) a. No, this model may be too simple in its present form, but is still useful. Try again.

(wa) b. No, wouldn't it be nice if this simple model could explain everything? Remember, it did NOT correctly predict the speed of light in water as compared to air. Try again.

HINT: If you need a hint, look through the previous problems.

This completes the examples on the PSSC film covering the measurement of the speed of light. Select the next section you would like to review from page 13 of the supplementary booklet.

Film204

The following six questions are designed to help you review the PSSC film on simple waves.

Problem 1: A "Slinky" (large-diameter steel spring), a small-diameter brass spring, and a rubber tube each have one end attached to a common, stationary bar. (The other end of each is attached to a cross-bar held in the experimenter's hand. (This enables him to launch a pulse on all three simultaneously.) When he moves the bar in his hand, a wave pulse is sent down the three "media" and is reflected back from the stationary bar. What happened??

a. waves on all three got back to the bar in his hand at the same time
b. the waves died out before getting back to the hand-held bar
c. the three waves got back at different times.

(ca) c. That's right.

(wa) a,b. No, the three waves got back at different times.

HINT: The speed with which a wave travels (known as the speed of propagation) depends very much upon the material the wave is traveling in.

Problem 2: Conclusion: The speed of the wave pulse depends on the nature of the medium in which the pulse moves. If two identical "Slinkies" are used, do the wave pulses get back at the same time or different times?

(ca) same. Correct.

(wa) different. No, they get back at the same time. Now type the correct answer.

HINT: The two "Slinkies" (springs) are made of the same material aren't they? Now answer the original question.

Problem 3: Conclusion: The speed of a wave is the same in two identical media. In the next example, the experimenter took up a few turns of one of the two Slinkies in his hand, making this one tighter than the other. What was the result?

a. the wave pulse traveled faster on the tighter Slinky
b. the wave pulse traveled slower on the tighter Slinky
c. the speed was the same on both Slinkies.

(ca) a. You have a good memory. But why did this happen?

(wa) b. No, it traveled faster on the tighter Slinky. But the main point is that the speed was different on the two springs, which you did remember. Now enter the correct answer by typing the proper letter.

(wa) c. No, the speed was different on the two Slinkies. Try again.

HINT: The tighter Slinky is no longer the same medium as before, it has been deformed by stretching. What will this do to the speed of the wave pulse?

Problem 4: Conclusion: Even in the same material, changing the mechanical state or condition of the medium will cause a change in speed of the wave pulse. This time a single coil was used. A rotating switch triggered flashbulbs so that photographs were taken of the progress of a wave pulse down the coil at intervals of 1/20th of a second. Six positions were photographed against a measured table, so the distance traveled by the pulse in each successive interval could be measured. It was found that

a. the pulse traveled more and more slowly as it progressed along the coil
b. the pulse split into a number of components
c. the pulse traveled equal distances in the equal time intervals.

(ca) c. Yes.

(wa) a. No, the distance traveled in one interval was the same all along the path. The amplitude, or size of the displacement, decreased slightly as it progressed.

(wa) b. No, the wave shape remained essentially constant. The picture, being a multiple exposure of six positions of the wave, showed six "peaks", but these were all the same wave, photographed in different positions.

HINT: Think of the reasons underlying the correct answer to the previous question.

<u>Problem 5</u>: Conclusion: A wave will travel with a constant speed in a uniform medium. To observe whether the speed of a wave depends on its size or shape, Dr. Shive used a steel bar with many crossbars attached to it. When a twist is given to the steel bar, the ends of the cross-bars display a transverse wave pattern. He measured the time for three types of waves to travel the length of the rod and back. These three waves were:

1. A small wave made by lifting only the first cross-bar.
2. A larger wave made by lifting the first cross-bar a larger amount.
3. A small wave of a different shape made by lifting the first cross-bar sharply.

Which wave took the longest time to traverse the distance?

a. the first wave
b. the second wave
c. the third wave
d. none of these

(ca) d. Right. All three took the same length of time, within the accuracy of the measurement.

un Conclusion: The speed of a wave does not depend on its size or shape. All three took the same length of time, within the accuracy of the measurement. Now type the letter of the correct answer.

<u>Problem 6</u>: It's important to remember that the generalizations in this film concerning wave properties apply only to waves of small amplitude. For very large amplitude, they hold only approximately. The last experiment was to see what happens when a wave goes from one medium to a second medium in which the speed is different. Dr. Shive used two torsion-bar machines, whose cross-bars were of two different lengths, and connected them end-to-end. A wave pulse started on one end of the faster medium was transmitted through the boundary to the second medium. The pulse moved more slowly in the second medium Dr. Shive repeated the experiment so you would notice something else of importance that happened. What else besides transmission happened to the wave at the boundary between the two media? (This can be answered without using a complete sentence.)

(ca) reflected   Very good, you kept your eyes open and saw that the wave was partially reflected.

(wa)   The answer is partially reflected. Enter that.

Conclusion: A wave is partially transmitted, partially reflected at a boundary between two different media. This may remind you of what happens to light in going through an air-water interface, an interesting similarity. You have now completed the section which reviews the PSSC film on simple waves. Consult page 13 of the supplementary booklet and choose the section you wish to review next.

Film201

The following six questions are designed to help you recall the principles discussed in the PSSC film dealing with optics.

Problem 1: This film opened with a discussion of shadows. Some were sharp. Others, such as the shadow of the earth on the moon, were fuzzy. This type of fuzziness is due to

a. diffraction
b. refraction
c. large size of the light source

(ca) c. Right. The sun is such a large source that light rays from different parts of the source throw a shadow of the earth's edge in different positions, so that the shadow of the edge is not sharply defined.

(wa) a. No. It is important to distinguish between the effects of diffraction and the fuzziness due to the fact that the light source is not small.

(wa) b. No, refraction is the bending of a light ray as it goes from one medium to another. Except for a short trip through the earth's atmosphere, the sun's rays travel through vacuum.

HINT: The sun is very large.

Problem 2: The sharpness of the shadow of an opaque object illuminated by a SMALL source is evidence for the straight-line propagation of light. However, the film illustrated four ways in which light can be bent. Write the name of the method of bending that is exemplified by each of the following cases:

1. The beam of light from a movie projector can be seen in a smokey room.

(ca) scattered. Correct.

un Since the beam is projected at the screen, how does some of the light from the beam get bent toward your eyes as you view the beam from one side?

Problem 3: A fish-eye view, from beneath the surface of a lake, of a frog sitting on a stick above the water.

(ca) refracted Very good.

un The light ray from the frog to the fish's eye has to go from air into the denser medium, water.

Problem 4: While driving in heavy traffic on a summer's day, you are temporarily blinded by the sun shining on a nearby car.

(ca) reflection That's right.

(wa) Some of those cars were as shiny as a mirror.

Problem 5: In the film, when the tongue depressors were brought very close together, light and dark bands began to show between the depressors as well as in the shadow itself. This is caused by which phenomenon?

(ca) diffraction Good.

un The particle model cannot explain these bands.

Problem 6: To sum up, four ways of bending light were described: reflection, refraction, diffraction and scattering. Of these four, three depend on the interaction of light and matter, and therefore on the physical properties of the materials employed. One method of bending does not depend on the material involved. Which one:

(ca) diffraction. Very good.

un This was the method which was demonstrated by the tongue depressors. You remember what that was?

You have now completed the section which reviews the PSSC film which discussed optics. Consult page 13 of the supplementary booklet and select the next section you would like to review.

Finrev

We have constructed two sample reviews of 26 questions covering the major concepts of Physics 107.

Finrev

Problem 1: Notation. In proper scientific notation. $\frac{5,000 \times 36}{400}$

a. 4.5×10^2

b. 45×10^1

c. 0.45×10^3

d. 4500

(ca) a. That's correct.

(wa) bcd. Wrong. A number is expressed in scientific notation as N.P. X 10^n where n is an interger between 1 and 10 and n is the number of times N.P. is multiplied by ten to position the decimal point. Convert the data to scientific notation, compute the answer and convert it to good scientific notation. (See page 5 of the booklet.)

Problem 2: Order. What is the order of magnitude of the number of pennies in $5,384,926.33?

a. 10^6

b. 10^7

c. 10^8

d. 10^9

(ca) d. Your answer is correct.

(wa) a,b. Wrong, multiply the number of dollars by 100 cents/dollar to get the number of cents, then convert to scientific notation and find the order of magnitude.

(wa) c. You're close, but remember to find the nearest (could be either higher or lower) power-of-ten to the number.

HINT: The order of magnitude is the nearest (could be either higher or lower) power-of-ten to the number involved. (See page 5 and 5A of the booklet.)

Problem 3: The following forces act on a 5 kg body: 49 newtons down, 5 newtons west, 10 newtons north, 49 newtons up, 5 newtons east. What is the net force acting on the body?

a. 20 newtons west

b. 10 newtons north

c. zero

d. 10 newtons.

(ca) b. Very good. You seem competent at vector addition.

(wa) a,c. No. I suggest that you draw a diagram.

(wa) d. That's partly right, but in what direction does the net force act? Type the proper letter.

HINT: Draw a picture.

Problem 4: A man is reduced by 1/2 in all linear dimensions, therefore:

a. he will be stronger for his weight
b. he will be weaker for his weight
c. his strength to weight ratio remains the same.

(ca) a. Correct.

(wa) b,c. Wrong, strength varies as the square of the scaling factor and weight as the cube. Try again.

HINT: Strength varies as the square of the scaling factor and weight as the cube.

Problem 5: In the relationship $Q = 1/2\ (PR/R^2)$. If P and B remain constant, Q will change by what factor if R changes by a factor of 3?

a. 1/3 c. 9

b. 6 d. 1/9

(ca) d. Correct.

(wa) c. Remember that this is an inverse square relationship. Try again.

(wa) a,b and HINT:
Try substituting some numbers for P,B, and R and see how Q changes as you multiply R by 3.

Problem 6: A certain auto, which is known to be absolutely airtight when the windows and doors are closed, is allowed to stand in the sun and experience a temperature increase of 27°. The original temperature was 273° absolute and the original pressure was 14 lbs/in^2. What is the final pressure?

a. 37.8 lbs/in^2 c. 15.4 lbs/in^2

b. 14 lbs/in^2

(ca) c. That's very good.

(wa) a,b. The temperature changes by a factor of 300/273, therefore the pressure will change by the same factor. (300/273 = 1.1)

HINT: The pressure will change by the same factor as the temperature.

Problem 7: The image you see of a toothpick 15 cm from a plane mirror is

a. 15 cm behind the mirror, upright and real
b. 15 cm behind the mirror, perverted, and real
c. 15 cm in front of the mirror, and virtual
d. 15 cm behind the mirror, upright and virtual

(ca) d. Good work.

(wa) a,b. Are you sure that the image is real? Can it be focused? Try again.

(wa) c. No. The object is 15 cm in front of the mirror, not the image. Try again.

HINT: Can the image be focused? Is it in front or behind the mirror? Answer the original question now.

Problem 8: A certain liquid has an index of refraction of 1.5. A beam of light enters this liquid from a glass pane with an index of refraction of 1.5 at an angle of incidence to the liquid of 23°. Therefore, the angle of refraction is -

a. greater than 23°

b. 23°

c. less than 23°

(ca) b. Right.

(wa) a,c. Wrong, note that the beam of light is going from one medium to an equally dense medium since the indices of refraction are the same.

HINT: Does the light go from a less dense to a more dense medium or what? Answer by typing the proper letter.

Problem 9: The particle model of light accurately explains

a. the laws of reflection
b. that the speed of light in water is less than in air
c. small slit diffraction patterns.

(ca) a. Correct.

(wa) b. Wrong. For observed angles of refraction, the particle model must postulate a higher velocity in water. Try again.

(wa) c. Wrong. The particle model of light has trouble explaining diffraction patterns.

HINT: This is a memory question. If you have trouble, review your notes and go through the particle model review.

Problem 10: A wave 10 meters long passes an observer in 5 seconds. The frequency of this wave is

a. 1/5 cps

b. 2 m/sec

c. 50 m/sec

(ca) a. You're pretty good.

(wa) b,c. Nope. Remember that frequency is the reciprocal of the period.

HINT: $f = 1/T$.

Problem 11: Two pressure wave trains cross each other out of phase. The damage caused by these wave trains in the crossing area is

a. greater than elsewhere along their path
b. less than elsewhere along their path
c. the same as elsewhere along their path.

(ca) b. Right.

(wa) a. No, think about out of phase wave interactions for a moment and try again.

(wa) c. Wrong. There will be either more or less damage in the crossing area. Try again.

HINT: The amplitude of the wave is the damage-causing agent.

Problem 12: The wave model of light predicts that

a. light travels faster in glass than in air
b. light travels slower in diamond than in air
c. light travels the same speed in air as in a vacuum.

(ca) b. Good.

(wa) a. No. The particle model predicts that.

(wa) c. Wrong, light travels at slightly different speeds in air and in a vacuum.

HINT: Light travels slower in the dense medium of water than in the less dense medium of air.

Problem 13: A car starting from rest reaches a speed of 110 kilometers per hour in time of 11 seconds in a drag race. What is the car's average acceleration?

a. (11 km/hour)/sec

b. (1.21×10^3 km/hour)/sec

c. 1/6 km/sec^2

(ca) c. Very good. You saw that the acceleration was 110 km/hour/ 11 sec which is (10 km/hour)/sec or (10km/60 sec)/sec which is 1/6 km/sec^2.

(wa) a,b. & HINT: Wrong. Acceleration is the change in velocity per unit time. If you don't understand, follow this:
a = change in velocity/unit time substituting a = (110 km/ hour)11 sec a = (10 kn/hour)/sec since one hour = 60 sec, a = (10km/60 sec)/sec. a = ? I'll let you finish this calculation and answer by typing a, b or c.

Problem 14: You have a spring scale that measures in kilograms. You wish to use the scale to measure weight directly in newtons. You do this by changing the kilogram read-out numbers by a factor of __________.

(ca) 9.8 Correct.

HINT: Kilograms X meters/second^2 = newtons.

un No. Remember how you find weight from mass on the earth and try again.

Problem 15: What is the magnitude of the momentum of a 2 kg object, falling freely near the earth's surface one second after being released?

a. 9.8 kg·m/sec

b. 19.6 kg m/sec

c. zero

(ca) b. Excellent. You saw that the speed at the end of one second was 9.8 m/sec.

(wa) a,c. No, momentum is found by multiplying mass times velocity. Find what velocity a freely falling body reaches in one second and multiply that by the mass of the body.

HINT: Speed at the end of one second is 9.8 m/sec^2 X 1 sec = 9.8 m/sec.

<u>Problem 16:</u> A rock is thrown straight up with a kinetic energy of 30 joules. When the rock is halfway back down to the ground, what is its total energy?

a. 15 joules

b. 30 joules

c. 45 joules

(ca) b. Good. You saw that energy is conserved.

(wa) a. No. That is its potential energy when it is halfway down. I asked for <u>total</u> energy. Try again.

(wa) c. No. Remember that energy is conserved.

HINT: The total energy of the rock is the sum of its potential and kinetic energies.

<u>Problem 17</u>: How much work is done in accelerating a 10^3 kilogram locomotive at an acceleration of 10 m/sec^2 for a distance of 100 meters?

a. 10^6 joules

b. 3 X 10^3

c. zero

(ca) a. Good work.

(wa) b,c. No. The work is found by multiplying the component of force along the direction of motion by the distance moved.

<u>Problem 18</u>: An unknown number of forces is acting on an object that weighs 98 newtons on the earth's surface. If the object has an observed acceleration of 30 m/sec^2 what is the resultant of the acting forces?

a. 300 newtons

b. 2940 joules

c. 2940 newtons

d. 9.8 newtons

(ca) a. Good work.

(wa) b. No. Is force measured in joules? Try again.

(wa) c,d. Wrong. Remember F = MA.

HINT: Force is equal to <u>mass</u> times acceleration.

Problem 19: If an electric motor is doing 30 joules of work per second, how much electric power is it using?

a. 30 volts

b. 30 joules

c. 30 watts

(ca) c. Right.

(wa) a,b. Electric power has dimensions of amp X volt which is a
& HINT: joule/sec or a watt.

Problem 20: The magnetic field of the earth is about 5×10^{-5} weber/m^2 strong. What is the magnetic flux through a coil of wire (perpendicular to the magnetic field) that encloses $3m^3$.

a. 8×10^{-5} weber

b. 1.5×10^{-4} weber

c. 1.5×10^{-5} weber

(ca) b. Right.

(wa) a,c. Wrong. Flux through an area is found by multiplying field strength by the area perpendicular to the magnetic field.

HINT: Webers/$m^2 \times m^2$ = ?

Problem 21: A magnet is at rest in a coil of wire. You pull the magnet out, producing a current in the coil. This current is of a direction to

a. exert another magnetic field to pull the magnet back into the coil
b. push the magnet out of the coil quicker
c. turn the magnet sideways in the coil.

(ca) Right.

(wa) b,c. No. Lenz's law says the induced current tries to maintain the status quo.

HINT: Apply Lenz's law to this problem.

Problem 22: How much work is done by moving 2 coulombs of charge across a potential difference of 300 volts?

a. 302 joules
c. 150 joules
b. 600 joules

(ca) b. Right.

(wa) a,c. The work done in this case is found by multiplying joules/coulombs by coulombs to get joules.

HINT: One volt is equal to one joule/coulomb.

Problem 23: Which of the following men used quantum mechanics to help explain atomic structure?

a. Thomson
c. Bohr
b. Rutherford

(ca) c. Right.

(wa) a,b. Wrong. Try again.

HINT: Try all of the answers.

Problem 24: If a baseball has a momentum of 20 kg m/sec and an electron has a momentum of 200 kg m/sec, then the electron has a

a. longer wavelength than the baseball
b. shorter wavelength than the baseball
c. their wavelengths cannot be oompared because the baseball doesn't have one.

(ca) b. Right, L is inversely proportional to momentum.

(wa) a. No. Remember L = h/p, try again.

(wa) c. Wrong. Any object with a momentum has an associated wavelength. Try again.

HINT: L = h/p.

Problem 25: Coulomb's law predicts that the electric field strength inside a highly charged hollow conducting sphere is

a. dependent on the charge and radius of the sphere
b. greater near the walls than in the center
c. zero

(ca) c. Right.

(wa) a,b. Wrong. Remember what happened in the film when the experimenter tried to get a charge from inside the sphere.

HINT: Go through the film403 review section for review of this law.

Problem 26: The Millikan experiment showed that

a. gravity is stronger than electric force
b. charge comes in multiples of basic units
c. X-rays destroy electric fields.

(ca) b. Right.

(wa) a. No. Millikan's experiment made use of the fact that electric forces can be stronger than gravitational forces.

(wa) c. Wrong. X-rays were used to change the charge on droplets in the electric field by ionization.

HINT: What charge is on an electron?

Finrevb

Problem 1: Convert 5,500,000,000,000.0 to good scientific notation.

a. 5.5×10^{10}
b. 5.5×10^{12}
c. 55.0×10^{11}
d. 0.55×10^{13}

(ca) b. Right.

(wa) a. I think you miscounted the number of zeros. Try again.

(wa) c,d. That is the number, but remember that the coefficient is expressed as a number between 1 and 10. Try again.

HINT: See page 5 of the booklet.

Problem 2: A manufacturing company produces 3,490 thingies a month. There are 49 individual components in each thingie. What is the order of magnitude of the number of thingie components used per month?

a. 10^2
b. 10^3
c. 10^4
d. 10^5

(ca) d. Correct.

(wa) abc. Nope. The number of thingie components is found by multiplying the number of thingies by the number of components per thingie. Convert that value to its order of magnitude (nearest power-of-ten).

HINT: The order of magnitude of a value is the <u>nearest</u> power-of-ten to that value.

<u>Problem 3</u>: What is the resultant of the following vectors? 5 units north, 5 units northwest, 10 units south, 4 units west, 5 units southeast, 5 units east.

a. 5 units

b. 5 units south

c. 5 units southeast

(ca) b. You seem to be able to handle vector addition.

(wa) a,c. Wrong. I suggest that you draw a scale diagram.

HINT: Draw a picture.

<u>Problem 4</u>: A mythical animal called a Gnek (a very friendly beast) has toes just strong enough to hold its enormous weight off of the ground. If the Gnek's linear dimensions are scaled up by a factor of 2, its

a. belly will drag because it's toes's strength increased by a factor of 4 while its weight increased by a factor of 8
b. heat production increases by 4 while its heat loss increases by 8 so it will freeze to death
c. eyes won't work because the lenses' focal distance will change by a factor of 2 while the distance from the lens to the retina changes by a factor of 8.

(ca) a. That's exactly right.

(wa) b. Wrong. Heat production increases as the cube of the scaling factor ($2^3 = 8$) while heat loss increases by the square ($2^2 = 4$) so the Gnek will heat up, not cool off. Try again.

(wa) c. That's partly right, the focal distance increases by 2, but the distance to the retina also increases.

HINT: Strength varies as the square of the scaling factor and weight varies as the cube.

Problem 5: In the relationship $P = \frac{2KBC}{RDA^2}$. P is

a. linearly proportional to Q
b. inversely proportional to the square of A
c. inversely proportional to D
d. linearly proportional to C
e. all of these.

(ca) e. Very good.

(wa) abcd. Wrong, examine the relationship closely and compare the suggested answers for accuracy.

HINT: If you don't know what linearly proportional and inversely proportional mean, call the proctor for an explanation.

Problem 6: You note that the gas in a sealed container experiences a twofold pressure increase. You know that the volume and weight of the gas have remained constant. Therefore, you conclude that

a. the temperature has also remained constant
b. the temperature has been changed by a factor of 1/2
c. the temperature has been increased.

(ca) c. Very good.

(wa) a,b. Wrong, pressure is directly proportional to temperature. Try again.

HINT: If the temperature of an enclosed gas increases the pressure will also increase.

Problem 7: In reflection

a. the normal to the surface forms an angle of 90° with the plane formed by incident and reflected beam
b. the normal to the surface forms an angle of 0° with the plane formed by the incident and reflected beams
c. the reflected beam forms a 90° angle with the plane formed by the incident beam and the normal to the surface.

(ca) b. Correct, you remembered that the incident beam, reflected beam and the normal all lie in the same plane.

(wa) a. Wrong. That would mean that the incident and reflected beams would travel along the surface.

(wa) c. Wrong. See page 172 of your text (Van Name).

HINT: See page 172 of your text (Van Name).

Problem 8: The index of refraction

a. gives the ratio between the angle of incidence and angle of refraction
b. gives the ratio tan i/tan r
c. gives the ratio of the speed of light in air to the speed of light in the other medium
d. none of these

(ca) c. Good, it is also sin i/sin r.

(wa) a,b. Wrong, index of refraction is equal to the sin of the angle of incidence divided by the sin of the angle of refraction, which tells us that it also gives _____(answer by typing the proper letter).

(wa) d. No, one of the above is the correct answer.

HINT: The sin of an angle compares the component in one direction to its total magnitude.

Problem 9: The particle model of light had to be modified when

a. the index of refraction was defined
b. it was found that the speed of light in water was less than in air
c. quantum mechanics was discovered.

(ca) b. Good.

(wa) a. No. The particle model of light can explain refraction.

(wa) c. No, the real stumbling block had to do with light traveling in other media other than air.

HINT: If you're having trouble review your notes and go through the particle model review section.

Problem 10: A wave whose frequency is 200 cps has a wavelength of .03 m. What is the wave's velocity?

a. 1/6 m/sec
c. 6 m/sec
b. 1.5×10^{-4} m/sec

(ca) c. Good work.

(wa) a,b. Come on now, you know velocity of a wave is found by $v = Lf$ where L is wavelength. Try again.

HINT: Frequency is measured as cycles/sec. Wavelength is measured as meters/cycle. Velocity is measured as meters/sec. Mull over that and use it to answer the question.

Problem 11: In which of the following is the wave model's predictive ability better than the particle model's?

a. reflection

b. refraction

c. scattering

d. diffraction

(ca) d. Right.

(wa) abc. Wrong. That can be accurately predicted by the particle model.

HINT: Can the particle model explain interference patterns? Now answer correctly.

Problem 12: Two wave trains of equal amplitude of 2 cm, equal velocity of 500 m/sec, and frequency of 20 cycles/sec find themselves crossing each other completely out of phase. What is the net displacement of the medium in the crossing area?

a. 4 cm

b. 2 cm

c. zero

(ca) c. Good thinking.

(wa) a. You're wrong. I said out of phase not in phase. Try again.

(wa) b. Some interference will occur when the wave trains cross. Which of the remaining two answers is the correct one?

HINT: Out of phase waves undergo destructive interference.

Problem 13: If a 6 newton force is acting on a 3 kg body, what acceleration will be observed?

a. 2 m/sec^2

b. 18 m/sec^2

c. 3 m/sec^2

(ca) a. Right.

(wa) b,c. Wrong, remember F = ma.

HINT: F = ma.

Problem 14: The acceleration due to gravity on a certain planet is 5 times that of the earth's. If a space explorer has an inertial mass of 80 kg, how much will he weigh on that planet?

a. 400 kg

b. 3920 newtons

c. 3.92×10^4 newtons

d. 3.41×10^3 newtons

(ca) b. Your calculations were correct.

(wa) a. No. Kilograms measure mass, and an object's mass remains constant throughout the universe. Try again.

(wa) c,d. Wrong. The explorer's weight is found by multiplying his mass by the acceleration due to gravity.

HINT: Weight is gravity times mass.

Problem 15: A 3 kg lump of clay traveling with a velocity of 6 m/sec has a completely inelastic collision with a wall. What is total momentum of the wall and lump of clay before the collision?

a. 18 kg m/sec

b. 2 kg m/sec

c. zero

(ca) a. Good.

(wa b. No, momentum is mass times velocity. Try again.

(wa) c. No, I said before the collision, not after it.

HINT: Note that I said before the collision.

Problem 16: A 300 kg mass is accelerated from rest to a velocity of 30 m/sec. What is the total energy possessed by the object as a result of this acceleration?

a. 1.35×10^4 joules

b. 1.35×10^5 joules

c. 2.7×10^5 joules

d. 100 joules

(ca) b. Very good.

(wa) a. That's just about it. Be more careful with the order of magnitude and try again.

(wa) c. Wrong. You forgot the 1/2. Try again.

(wa) d. No. K. E. = $1/2\ mv^2$.

HINT: The energy is evident as kinetic energy.

Problem 17: How much work is done carrying a 30 kg object up 10 meters of stairs?

a. 3.49×10^3

b. 3 joules

c. 2.94×10^3

d. 300 joules

(ca) c. Good.

(wa) a. No. Find out how much potential energy the object gained. Then answer correctly.

(wa) b,d. No. Work done is equal to potential energy gained.

HINT: Work done is the component of force acting on an object times the distance the object moved under the influence of that force.

Problem 18: A continuous, pure deflecting force is acting on an object with an instantaneous velocity of 12 m/sec. What path does the object follow under the influence of the deflecting force?

a. a straight line

b. a sharp angle

c. a circle

d. no path is followed, the object stops.

(ca) c. Good work.

(wa) a. Wrong. Remember that a deflecting force causes a change of direction in a moving object's path.

(wa) b. Wrong, it's true that a directional change occurs, but not all at one point.

(wa) d. Wrong, we're talking about a deflecting force, not a decelerating force.

HINT: This question is analogous to the ideal satellite orbiting the earth.

Problem 19: What is the potential difference across a light bulb whose resistance is 2 ohms and has a current of 3 amps through it?

a. 2/3 volt

b. 1.5 volts

c. 6 volts

(ca) c. Right.

(wa) a,b. No. Recall Ohm's law and apply it.

HINT: $V = RI$

Problem 20: The magnetic field strength produced by a current flowing through a long, straight conductor is

a. inversely proportional to the current
b. proportional to the current squared
c. directly proportional to the current

(ca) c. Right.

(wa) a. No. That would mean that a high field strength would exist when no current flowed.

(wa) b. No. It's true that the strength increases when more current flows, but not exponentially.

HINT: See page 129 of your text (Van Name).

Problem 21: The magnetic field of the earth runs north-south and has a strength of 5×10^{-5} weber/m^2. A 1000 turn coil of an area of 5 m^2 is rotated on an east-west axis at 600 revolutions per minute. What EMF is produced in that coil? (As it rotates from a plane parallel to the earth's surface to one perpendicular to the earth's surface.)

a. 10 volts

b. 1.5×10^{-2} volts

c. 3.0×10^{2} volts

(ca) a. Very good.

(wa) b,c. No. The EMF produced is found for <u>one</u> turn of the coil by $EMF = \frac{\text{change of flux (webers)}}{\text{time (seconds)}}$. Try again.

HINT: Determine how long it takes the coil to revolve through the specified arc.

Problem 22: A charge of 6 coulombs is near another charge of 3 coulombs. The force between these two charges is

a. attractive

b. repulsive

c. 18 newtons

(ca) b. That's right.

(wa) a. No, remember that like charges repel. Try again.

(wa) c. No, how can you find the force between the charges without knowing the distance? Try again.

HINT: If you need a hint for this one, you're hurting.

Problem 23: Which of the following men proposed the "rasin pudding" atomic model?

a. Thomson

b. Rutherford

C. Bohr

(ca) a. Right.

(wa) b,c. Wrong. Try again.

HINT: Try all of the answers.

Problem 24: The energy of a photon is found by multiplying Plank's constant by

a. its mass

b. its velocity

c. its frequency

(ca) c. Right.

(wa) a. Wrong. The mass of a photon is found by the relationship $L = h/mv$ solving for m, $m = h/vL$. Try again.

(wa) b. No. The velocity of a photon is determined by the medium in which it travels. Try again.

HINT: $E = hf$.

Problem 25: An attractive force of 1.5×10^{-2} newtons exists between two small charged bodies 3 cm apart. If the distance between the two bodies is changed to 1.5 cm the force between them becomes

a. 6×10^{-2} newtons

b. 3×10^{-2} newtons

c. 5×10^{-3} newtons

(ca) a. Right.

(wa) b,c. Wrong, force is inversely proportional to the square of the distance.

HINT: Coulomb's law says that $F = \frac{k\,Q(A) \times Q(B)}{d^2}$.

Problem 26: The Millikan experiment showed that

a. gravity is stronger than electric force
b. charge comes in multiples of basic units
c. X-rays destroy electric fields.

(ca) b. Right.

(wa) a. No. Millikan's experiment made use of the fact that electric force can be stronger than gravitational force.

(wa) c. Wrong. X-rays were used to change the charge on droplets in the electric field by ionization.

HINT: What charge is on an electron?

Optics

This section contains three questions about optical or light phenomena.

Problem 1: The particle model of light is a poor model because it cannot explain that

a. in reflection the incident, reflected, and normal all lie in the same plane
b. light travels faster in a vacuum than in any other medium
c. in reflection the angle of incidence is equal to the angle of reflection.

(ca) b. Excellent.

(wa) a,c. No, the particle model of light gives a very good explanation of the laws of reflection.

Problem 2: If the speed of light in air is 3×10^8 M/Sec what would be the speed of light passing through a diamond which has an index of refraction of 2.4?

a. 7.2×10^8 M/Sec

b. 1.25×10^8 M/Sec

c. 8.0×10^8 M/Sec

(ca) b. Well done!

(wa) a,c. No. Remember that the index of refraction is equal to the speed of light in air divided by the speed of light in a material medium ($n = c/v$).

Problem 3: Reflection, refraction, and diffraction

a. can all be explained by the particle model of light
b. can all be explained by the wave model of light.
c. cannot all be explained by any model of light.

(ca) b. Very good, you seem to understand the different models of light very well.

(wa) a. No, the particle theory can explain reflection but not diffraction. It can explain refraction in the sense of arriving at Snell's law, but does not correctly predict the speed of light in a refractive material. Now answer correctly.

(wa) c. Wrong. It happens one model can do it. Which one?

This ends the optics review section.

Unitsl

Read page 11 of the supplementary booklet while the typewriter prints the introduction to this section. As you will see in this review and subsequent work involving the physical sciences, the units of measurement play an important role in this work. Although you may not understand the terms presented here. You will eventually have to work with them in this course. Our object to presenting them at this time is to give you an understanding of the technique of working with the units of an equation before you work with the numbers--just to be sure you are working with the appropriate equation. To continue; are you familiar with the meaning of "units" or "units of measure"?

Type yes or no.

(ca) yes Good. The units you will need to use in Physics 107 are listed below:

(ca) no To refer to the "units" or "units of measure" of a quantity is to refer to the label assigned to this quantity. Some examples are shown below--with the units of the quantity printed in red. Examples of units of measure for

time	25 seconds	wages	\$2.00 per hour
speed	75 miles per hour	mass	50 kilograms
length	10 meters	force	25 newtons
	100 yards		50 pounds

un Type yes or no.

Important Units of Measure.

To measure	Use
length or distance	meters
time	seconds
mass	kilograms

All other units of measure are combinations of the three basic quantities--length, mass, and time.

force or weight	newtons
work done	joules
energy or power	joules
electrical charge	coulombs
electrical current	amperes
electrical energy	volts
electrical work or power	watts or joules

The problems which follow are examples of the need to work with units of measure. Three basic things to remember about units.

1. Units are treated in a normal algebraic manner.
2. Units can cancel as algebraic quantities.
3. The units on both sides of a relationship (equation) must be the same.

Problem 1: Complete the following: miles X kilometers/miles X meters/kilometers =

a. miles/meter

b. kilometers/miles

c. meters

d. I need help.

(ca) c. Good. You remembered the 3 basic points about units.

un Let's look closely at the problem, first, we multiply the first two terms. (miles X kilometers/miles) The miles cancel and we are left with kilometers. We then multiply kilometers by the third term (kilometers X meters/kilometers) and we get meters. Now what is the answer.

Problem 2: If we were to tell you that a newton was a kilogram X meter per second per second and that a joule is a kilogram X meter X meter per second per second.

$$\text{newton} = \text{kg m/sec}^2$$
$$\text{joule} = \text{kg m}^2/\text{sec}^2$$

What would you have to do to a newton to make it a joule?

a. multiply by meters

b. divide by meters

c. add meters

d. I don't know.

(ca) a. Good work.

(wa) b. No. Try again.

(wa) c. No. Try again.

(wa) d. Examine the break down of joules and newtons carefully and find the difference. The difference is that a joule has more meter multiplied by the kilogram than a newton. Now what will you do to get newton changed to a joule?

Problem 3: Suppose that you were X miles from your destination and you had Y hours to get there, how fast would you have to travel?

a. Y hours X miles

b. X miles/Y hours

c. Y hours/miles

d. I don't know.

(ca) b. Good. You know that speed is measured in length per unit time so you don't even need to know numbers to be able to answer.

(wa) a. No. The units of speed are length per unit time. Answer correctly.

(wa) d. You know that speed is usually shown as length per unit time. Now try again.

This concludes the review of units and units of measure. In summary; every essential property, such as the velocity, direction, volume or diameter that enters into the description of physical phenomena has its own units which differentiate it from other properties. Although every physical quantity has its own units, one will notice that all such quantities are made up of a very limited number of <u>fundamental dimensions</u>. When an equation representing a physical phenomenon is written down it is absolutely necessary that the equation be dimensionally homogeneous. That is, both sides of the equality sign must be expressed in the same units. If they are not, one can be sure that some important quantity was lost or misplaced in the derivation.

<u>Units3</u>

Now that we have explored what units are and some simple ways to use them, let's go on to some more complex problems in the use of units to formulate the solution of physics questions. We will concentrate on the units used to identify work, energy, force, weight, momentum, acceleration, and velocity. The new units that you encounter in this area are newtons and joules.

<u>Problem 1</u>: A newton is equal to a kg m/sec^2 (newton = kg m/sec^2). A joule is equal to a kg m^2/sec^2 (joule = kg m^2/sec^2). From this you can see that: newton X meter = _______.

(ca) joule That's right, let's continue.

un Look at the definitions of a newton and a joule again and note how they differ. A newton X meter is the same as kg m/sec^2 X meter, which is kg m^2/sec^2. Now what's that?

un A kg m^2/sec^2 is a joule. Type that in now.

<u>Problem 2</u>: Work is done by a force acting on an object while it moves through a distance. If an object moves through a distance of 8 meters under the action of a force of p newtons, how much work is done?

(ca) 8p joules

(wa) 8p newton-meters

HINT: If you really need a hint, call the proctor.

Problem 3: If mass is measured in kilograms (kg) and weight is measured in newtons, how do you convert mass to weight?

a. add m/sec^2

b. divide kg m^2/sec^2 by mass

c. 1/2 mv^2

d. multiply by acceleration

(ca) d. Good, you saw kg X m/sec^2 is equal to newtons.

(wa) a. No, that would give you (kg) + (m/sec^2), which is not a newton.

(wa) b. No, that would give you m^2/sec^2 which is velocity squared, not weight.

(wa) c. No, 1/2 mv^2 is an expression of kinetic energy.

HINT: You have kg, what do you need to get kg m/sec^2? Answer by typing a, b, c, or d.

Problem 4: Potential energy is measured in joules. What is the potential energy of a 10 kg mass, 10 meters above the earth's surface?

(ca) 980 joules

(wa) 100
10^2
1 X 10^2
1.0 X 10^2
No, that gives you kg m, think what else you need to get kg m^2/sec^2 and work the problem correctly.

HINT: From the units you have, you can see you need m/sec^2 which is an expression of acceleration. NOTE: The potential energy the object has is the result of the fact that the force of gravity can do work on the object. The acceleration of gravity is 9.8 m/sec^2.

un You seem to be having trouble, ask for a hint.

un The potential energy is found by inspecting the units to see what you need to get joules. You have kg and m and need to get kg m^2/sec^2. The potential energy of the object has is the result of the fact that the force of gravity can do work on the object. The acceleration of gravity is 9.8 m/sec^2. Type that in now.

You have now completed the units section and may choose the next material you would like to review. Turn to page 17 of the booklet and select the section you want.

Film307

The following five questions cover the material discussed in the PSSC film on frames of reference.

Problem 1: While a bus is in motion along a level, straight section of road, we roll a marble from one side to the other across the floor of the bus. (Assume the marble is not subject to any force from the bus.) Its path is a straight line relative to the bus. Therefore,

a. the bus is moving with constant velocity
b. the bus is either speeding up or slowing down
c. nothing can be said about the motion of the bus.

(ca) a. Very good. Once released, the marble is not subject to any force, so its path in an inertial frame must be a straight line. Since the path is also a straight line relative to the bus, the bus must also be an inertial frame, so must move with constant velocity.

(wa) b. Wrong. If the bus were accelerating, the marble's inertia would cause it to curve toward the direction opposite to the bus's acceleration. Try again.

(wa) c. Wrong, the path tells something about the frame of reference (the bus). Try again.

HINT: If the bus is accelerating, the marble will have an apparent acceleration (relative to the bus) opposite to the bus's acceleration.

Problem 2: On the same bus at a later time, we again roll the marble from one side to the other. This time the path is a parabola which bends toward the front of the bus.

a. the bus is moving with constant velocity forwards
b. the bus is accelerating forward
c. the bus is moving with constant velocity backwards
d. the bus is accelerating backwards
e. nothing can be said about the bus's motion.

(ca) d. Excellent. Since the marble has no force acting on it, in an inertial frame, yet has an apparent (relative to the bus) acceleration forward, the bus must be accelerating backward in the inertial frame.

(wa) a,c. No, if the bus were moving with constant velocity, the path would be a straight line, as in the previous question. Try again.

(wa) b. You correctly figured that the bus is accelerating, but remember that the path bends toward the front of the bus. Now answer correctly.

(wa) e. Wrong, the path does show something about the frame of reference (the bus). Try again.

HINT: A man riding on the bus sees an apparent acceleration of the marble toward the front of the bus. Yet we know that no force is acting on the marble in an inertial frame, so in an inertial frame the path must be a straight line.

Problem 3: A man sits on a railroad flatcar which is moving with a horizontal speed of 4 meters/second. He throws a ball vertically upward with a speed of 24 meters/second. When the ball comes back down, it

a. lands 8 meters behind the man
b. lands 8 meters in font of the man
c. hits the man on the head.

(ca) c. Right. He should have taken a course in physics.

(wa) a,b. Unfortunately no. Relative to the man, the ball has only a vertical component of velocity. What happened?

HINT: To an observer in a car waiting for the train to pass, the ball has the same horizontal speed as does the man.

Problem 4: An example of a "fictitious" force (that is, a force we introduce to correct for the acceleration of our frame of reference) is:

a. a centrifugal force
b. a centripetal (center-seeking) force
c. a force of reaction, such as the force with which the wall pushes back on you when you push on a wall.

(ca) a. Right you are. Centrifugal force is a term widely used and poorly understood. In an inertial frame, it does not exist.

(wa) b. Wrong, this is a real force. Remember when Dr. Hume held the ice puck with a pencil and a rubber band while the turntable on which he sat was rotated. The centripetal force caused a stretch in the rubber band that could be observed even by an observer not on the turntable. Try again.

(wa) c. No, this is a real force; it does not depend on your wall accelerating or rotating. Try again.

HINT: This "force" often gets blamed when our car's inertia makes it hard to follow a curve in the road.

Problem 5: "A frame of reference attached to the earth is an inertial frame of reference." This statement is

a. true

b. true to a first approximation

c. not true

(ca) b. Glad you caught that point. It is not strictly inertial because of the rotation of the earth about its axis and about the sun, but the accelerations involved are relatively small. So we can normally neglect them. To sum up: an inertial frame is one in which the law of inertia holds (i.e., one in which Newton's laws hold). An accelerated reference frame is a non-inertial reference frame.

(wa) a. It is almost true, but remember the earth's rotation, which must involve acceleration. Try again.

(wa) c. It is not strictly true, but very nearly. Please type in the correct answer.

HINT: The earth rotates about its axis and revolves about the sun.

Film313

The next 3 questions cover the PSSC film which deals with the conservation of energy.

Problem 1: All interactions in the universe are related through the quantitative framework expressed in the law of conservation of energy. Does this law ultimately rest on

a. experimental observations

b. theory

(ca) a. Correct; not on any single experiment, but on the fact that energy "bookkeeping" balances out time after time.

(wa) b. No, actually it is based on repeated experimental observations. Now answer correctly.

HINT: This film is an example of the basis for the conservation principle.

Problem 2: The possibility cannot be excluded that over the whole universe, of which we accurately observe only a small fraction, energy is not completely conserved. A valid observation of non-conservation would cause quite a stir in the field of physics! Please refer to the table on page 23 of the booklet, giving input and output energy from the power plant seen in the film. If you were a physicist interested in verifying the conservation of energy, the figure you would be worried about is ________ million B.T.U.'s.

a. 9

b. 429

c. 291

(ca) a. Right. If your measurements were completely accurate and took everything into account, you would expect the difference between input energy (729 million B.T.U.'s) and total output energy (720 million B.T.U.'s) to be zero. However, this small difference (a little over 1%) is attributed to experimental errors.

(wa) b. No, this is the total energy converted into useless forms, (the heat energy of the atmosphere and the harbor water). The engineer wants this figure kept as small as possible, for high plant efficiency; but the form of the energy, whether useful or not, is of no importance to the conservation principle. Try again.

(wa) c. No, this is the amount of useful energy output, and is important as far as plant efficiency is concerned. Our physicist is only interested in total measured output energy, whether useful or not. Try again.

HINT: How do the energy books balance?

Problem 3: In which of the following examples is energy NOT converted from one form to a different form?

a. the brake drums get hot when a car goes at constant speed down a steep hill
b. a car's battery is used to start the motor
c. two steel balls collide in an elastic collision.

(ca) c. Right; in an elastic collision, kinetic energy is conserved.

(wa) a. Wrong. Gravitational potential energy is converted into heat energy, since the car does not speed up. Try again.

(wa) b. Wrong. The electrical potential energy of the battery is converted into mechanical energy of the turning motor.

Film305

The next four questions discuss the concepts covered in the PSSC film on Deflecting Forces. Now see page 21 of the booklet.

<u>Problem 1</u>: When a projectile is moving on its parabolic path, does the force of gravity act as a pure deflecting force on the projectile?

(ca) no Quite right. The force of gravity, which always points straight down is perpendicular to the velocity only when that velocity is parallel to the ground--at the top of the path just before the body begins to come down. So we'll have to find some other type of motion to study pure deflecting forces.

(wa) yes Wrong. The force of gravity points straight down. Is the path of the projectile at all times at right angles to the direction of gravitational forces?

HINT: See the introduction in the booklet page 21 for the meaning of a deflecting force.

<u>Problem 2</u>: Dr. Frank used a frictionless disk attached by a string to a center post, with a rubber ring inserted to "measure" the force in the string. He started the disk in uniform circular motion about the post, and photographed the motion throughout the circle. Was the amount of stretch of the rubber ring the same at every position in the circle?

(ca) yes Right you are, and this showed that the force acting through the string was constant. The string, which lies along a radius of the circle, IS always at right angles to the disk's path. So a constant pull at right angles will produce a curve constantly and uniformly bent everywhere. Such a curve is a circle.

(wa) no On, yes it was. See the photograph on page 344 of PSSC <u>Physics</u> second edition, in the CAI conference room. Then answer correctly.

HINT: This is a yes-or-no memory question. See the photograph on page 344 of PSSC <u>Physics</u> second edition in the CAI conference room, then answer the question.

Probl_m 3: More about uniform circular motion. By drawing the position, velocity, and acceleration vectors on a turntable, Frank could derive an expression for this centripetal (center-seeking) acceleration in terms of the radius R and the period of rotation, T. Write an equation for speed v in terms of R and T. (Remember, circumference = 2 pi R.)

(ca) v12pir/t

Excellent! You could go on from there to obtain the expression for acceleration.

HINT: Speed has dimensions of distance divided by time. What distance does the point of the radius vector travel in one period, T?

Problem 4: In the uniform circular motion experiment (two questions back) Frank used the same size force as Purcell did in his straight-line experiments in the Inertia film. Was the magnitude of the acceleration for circular motion found to be the same as for straight-line motion?

(ca) yes Eureka! It was. This shows that the inertial mass of the body is the same for circular motion as for straight line motion, and suggests that Newton's law is a vector law, with mass a scalar quantity. See page 22 of the booklet for the conclusions.

(wa) no You're wrong, but be happy for the physicists that the answer is yes (type that in).

HINT: This movie had a happy ending; everything checked out. What's the answer.

Exam3A

Read page 20 of your booklet.

Problem 1: Of the three basic forces in nature, which is the weakest?

(ca) grvt Correct.

un Wrong.

Problem 2: If you, a feather, and a kilogram of lead were dropped from 30 feet above the surface of the moon, which one would attain the highest velocity down? (Please use a one word answer.)

(ca) neither Correct.

un Wrong.

Problem 3: The work done to keep a 50 kg satellite in a circular orbit 400 km above the earth is ________.

(ca) zero Correct.

un Wrong.

Problem 4: A football player with a mass of 100 kg is running down field with a velocity of 1 m/sec to catch a pass. He isn't looking where he's going and has an inelastic collision with the stadium wall. How much thermal energy is created from the collision?

(ca) 50 joules Correct.

un Wrong.

Problem 5: A space explorer whose mass is 75 kg finds that his weight on an unnamed planet is 75 newtons. The acceleration due to gravity on this planet is ______ times that of the earth's.

(ca) 1/9.8 Correct.

un Wrong.

Problem 6: Assuming elastic collision, a car of mass 1000 kg collides with a truck of mass 2000 kg. If the speed of the truck changes by an amount of 10 m/sec, then the momentum of the car will change by ______.

(ca) 20,000 kg m/sec Correct.

un Wrong.

Problem 7: A car of mass 1000 kg is moving with a kinetic energy of 10^4 joules. How much work was done to get the car moving with that energy? (Neglect all forces of friction.)

(ca) 10,000 joules Correct.

un Wrong.

Problem 8: A bullet that weighs 20 newtons is shot straight up from the surface of the earth. It leaves the muzzle of the gun with a kinetic energy of 5,000 joules. It rises to a maximum height, H, and then falls back down. Neglecting air resistance, the potential energy of the bullet at height, H, is __________.

(ca) 5×10^3 joules Correct.

un Wrong.

Problem 9: Neglecting air resistance, the height, H, to which the bullet in question 8 rises is __________.

(ca) 250 m Correct.

un Wrong.

Problem 10: An object is observed to have a constant acceleration of 20 m/sec^2 east. A constant force of 100 newtons west is applied to the object and it stops accelerating and moves with a constant velocity east. The mass of the object must be __________.

(ca) 5 kg Correct.

un Wrong.

Problem 11: Two billiard balls, A and B, undergo an elastic, head-on collision. If A were initially at rest and B were initially moving with a velocity of 10 m/sec southeast and each ball has mass 400 grams. The kinetic energy of A, after the collision is __________.

(ca) 20 joules Correct.

un Wrong.

Problem 12: The momentum of ball B in question 11 will be ______ after the collision.

(ca) zero Correct.

un Wrong.

Problem 13: The work an athlete of mass 60 kg does when he accelerates himself from rest to a running speed of 1.2 m/sec is ________.

(ca) 43.2 joules Correct.

un Wrong.

Problem 14: Three unknown forces cause an object which weighs 980 newtons to accelerate at a constant rate of 30 m/sec^2 east. The magnitude of resultant of the three forces must be ________.

(ca) 3000 n Correct.

un Wrong.

Problem 15: A person whose mass is 80 kg is on the 10 meter diving board. Therefore, he has a potential energy due to gravity of 7840 joules. He steps off of the board and falls. In the first 5 meters of his fall he loses 3920 joules of potential energy. Neglecting air resistance, the diver's total energy at the 5 meter point is ________.

(ca) 7840 joules Correct.

un Wrong.

Problem 16: You wish to punish your younger sister for being annoying. In order to do this, you throw a 0.5 kg physics book at her with a speed of 3 m/sec. The energy that is expended with such a satisfying thump on her head is ________.

(ca) 2.25 joules Correct.

un Wrong.

Problem 17: There are two flies on a long-play record revolving on a turntable. Fly A is on the edge of the record, 16 centimeters from the center, and its tangential speed is 1 m/sec. Fly B is nearer the center, and its tangential speed is 0.5 m/sec. The distance that fly B must be from the center is ________.

(ca) 8 cm Correct.

un Wrong.

Problem 18: If the acceleration of fly B in question 17 is 0.1 m/sec^2, then that of fly A must be __________.

(ca) .2 m/sec^2 Correct.

un Wrong.

Problem 19: The sum of the work done on fly A and fly B in question 17 is _____________.

(ca) zero Correct.

un Wrong.

Problem 20: A man whose mass is 90 kg is standing on the gym floor upstairs; therefore, the floor pushes on his feet with a force of _________.

(ca) 882 n Correct.

un Wrong.

Exam3B

Problem 1: Of the basic forces of nature, which is the weakest?

a. gravitational

b. electrical

c. nuclear

(ca) a. Correct.

(wa) b,c. Wrong.

Problem 2: If the following were 30 feet above the surface of the moon, and were dropped from rest, which one would attain the highest velocity?

a. you

b. a feather

c. a pound of lead

d. all would attain the same velocity.

(ca) d. Correct.

(wa) abc. Wrong.

Problem 3: The work done by the force of gravity to keep a satellite in orbit

a. increases its kinetic energy

b. increases its potential energy

c. increases the magnitude of its velocity

d. is zero

(ca) d. Correct.

(wa) abc. Wrong.

Problem 4: A football player with a mass of 100 kg is running down field with a velocity of 1 m/sec to catch a pass. He isn't looking where he is going and has an inelastic collision with the stadium wall. How much thermal energy is created from this collision?

a. 980 joules

b. 10^2 joules

c. 50 joules

(ca) c. Correct.

(wa) a,b. Wrong.

Problem 5: A space explorer whose mass is 75 kg finds that his weight on planet 60019X is 75 newtons. The acceleration due to gravity on this planet is ________ times that of earth's.

a. 1

b. 1/9.8

c. 1/75

(ca) b. Correct.

(wa) a,b. Wrong.

Problem 6: Assuming elastic collision, a car of mass 1000 kg collides with a truck of mass 2000 kg. If the speed of the truck changes by an amount of 10 meters/sec, the momentum of the car will change by

a. 3×10^4 kg m/sec

b. 2×10^3 kg m/sec

c. 2×10^4 kg m/sec

d. 1×10^4 kg m/sec

(ca) c. Correct.

(wa) abd. Wrong.

Problem 7: A car of mass 10^3 kg, is moving with a kinetic energy of 10^4 kg m^2/sec^2. How much work was done to get the car moving with that kinetic energy? (Neglect all forces of friction.)

a. 10 joules

b. 10^4 joules

c. 10^7 joules

(ca) b. Correct.

(wa) a,c. Wrong.

Problem 8: A bullet that weighs 20 newtons is shot straight up from the surface of the earth. It leaves the muzzle of the gun with a kinetic energy of 5000 joules. It rises to a height, h, and then falls back down. The potential energy of the bullet at height, h, is ____. (Neglect air resistance.)

a. 10,000 joules

b. 200 newton meters

c. 5 X 10^3 kg m^2/sec^2

(ca) c. Correct.

(wa) a,b. Wrong.

Problem 9: The height, h, to which the bullet in question 8 rises is ______ (neglect air resistance).

a. 5000 meters

b. 250 meters

c. 10^5 meters

(ca) b. Correct.

(wa) a,c. Wrong.

Problem 10: An object is observed to have a constant acceleration of 20 m/sec^2 east. A constant force of 100 newtons west is applied to the object and it stops accelerating and moves with a constant velocity east. The mass of the object must be __________.

a. 5 kg

c. 4 kg

b. 20 kg

(ca) a. Correct.

(wa) b,c. Wrong.

Problem 11: Two billiard balls, A and B undergo an elastic, head-on collision. If A were initially at rest, and B were initially moving with a velocity of 10 meters per second southeast and each ball has mass 400 grams, then what will the kinetic energy of A be after the collision?

a. zero

c. 40 joules

b. 20 joules

(ca) b. Correct.

(wa) a,c. Wrong.

Problem 12: What will the momentum of ball B of question 11 be after the collision?

a. 4 kg m/sec

c. zero

b. 4000 kg m/sec

(ca) c. Correct.

(wa) a,b. Wrong.

Problem 13: How much work does an athlete do when he accelerates himself from rest to a running speed of 1.2 m/sec if his mass is 60 kg?

a. 43.2 joules

c. zero

b. 72 kg m/sec^2

(ca) a. Correct.

(wa) b,c. Wrong.

Problem 14: Three unknown forces cause an object which weighs 980 newtons to accelerate at a constant rate of 30 m/sec^2 east. What is the magnitude of the resultant of the three unknown forces?

a. 300 joules

b. 30 newtons

c. 3×10^3 kg m/sec^2

d. 9.8 newtons

(ca) c. Correct.

(wa) abd. Wrong.

Problem 15: A person whose mass is 80 kg is on the 10 meter diving board. Therefore, he has a potential energy due to gravity of 7840 joules. He steps off of the board and falls. In the first 5 meters he loses 3920 joules of potential energy. Neglecting air resistance the diver's total energy at the 5 meter height is

a. 3920 joules

b. 11760 joules

c. 7840 joules

d. zero

(ca) c. Correct.

(wa) abd. Wrong.

Problem 16: You wish to punish your younger sister for being annoying. In order to do this you throw a 0.5 kg physics book at her, with a speed of 3 m/sec. How much energy does the book expend on her head with such a satisfying thump?

a. 1.5 kg m/sec

b. 2.25 joules

c. 1.25 joules

d. 4.5 joules

(ca) b. Correct.

(wa) acd. Wrong.

Problem 17: There are two flies on a long-play record revolving on a turntable. Fly A is on the edge of the record, 16 cm from the center, and its tangential speed is 1 m/sec. Fly B nearer the center, and its tangential speed is 0.5 m/sec. The distance that fly B must be from the center is

a. 8 cm c. 2 cm

b. 4 cm

(ca) a. Correct.

(wa) b,c. Wrong.

Problem 18: If the acceleration of fly B in question 17 is 0.1 m/sec^2, then that of fly A must be

a. 0.05 m/sec^2 c. 0.2 m/sec^2

b. 0.1 m/sec^2

(ca) c. Correct.

(wa) a,b. Wrong.

Problem 19: The sum of the work done on fly A and fly B in question 17 is

a. 0.16 pi newton meters c. 0.12 pi joules

b. 0.24 pi joules d. zero

(ca) d. Correct.

(wa) abc. Wrong.

Problem 20: If a man with a mass of 90 kg is standing on the gym floor upstairs, with what force is the floor pushing on the man's feet?

a. 90 kg c. 892 newtons

b. 90 newtons

(ca) c. Correct.

(wa) a,b. Wrong.

Film302

The next five questions will cover the concepts introduced in the PSSC film on inertia. A nearly frictionless object was used to perform a series of experiments on the connection between force and motion. In each experiment, measurements made on flash pictures made at one-second intervals in front of a centimeter scale enabled Dr. Purcell to determine if the motion was accelerated, decelerated, or of constant velocity.

Problem 1: In the first experiment, Purcell gave the object one push, then photographed it as it slid freely across the surface with no force acting on it. The motion was

a. accelerated

b. decelerated

c. of constant velocity

(ca) c. Correct, the object moved in a straight line with constant speed. We might conclude that an object on which no force acts moves with constant velocity.

(wa) a,b. No, the measured distance traveled by the object in each one-second interval was 16 centimeters. Now answer correctly.

HINT: The maker mounted on the object moved 16 centimeters in each one-second interval.

Problem 2: Is it true that after the initial push, there were no forces acting on the body, assuming friction was completely eliminated by the carbon dioxide device?

(ca) no Correct. The pressure of the escaping carbon dioxide gas pushes up, but is balanced by the weight of the puck pushing down. The conclusion should be modified to say that an object on which no unbalanced force acts moves with constant velocity.

(wa) yes Not really. What about the pull of gravity on the object? Please try again.

HINT: What about the pull of gravity on the object?

Problem 3: Experiment 2: A single constant force applied by Dr. Purcell's trained assistant to the object initially at rest. Which type of motion was observed?

a. accelerated

b. decelerated

c. of constant velocity

(ca) a. Right, the constant force produced uniform acceleration of the body in a straight line.

(wa) b. No, decelerated motion would mean the object was slowed down. This was impossible since the body was initially at rest.

(wa) c. Wrong. Constant velocity was observed in the first experiment, when no unbalanced force was acting on the body.

HINT: Compare this experiment with experiment 1 in the previous question.

Problem 4: In experiment 3 a larger constant force was applied to the object, initially at rest, by attaching two identical rubber rings to it and having them both pulled as in experiment 2. (We assume that the two rubber rings exert twice the force on the object that one did in experiment 2.) The acceleration, as measured by the difference in length traversed in successive one-second intervals, was ________ times as large as in experiment 2.

(ca) 2 Correct. We conclude that the acceleration is proportional to the applied force. In experiment 4 two rubber rings were again used; this time the threads pulling on the rings were not parallel, but formed a 60° angle. The resulting acceleration was in the direction of the vector sum of the forces. From these experiments, we've learned the following: It takes a force to change the motion of a body; if no force acts, the body moves at constant speed in a straight line. If we do apply a force to an object; the acceleration is proportional to the force.

HINT: The applied force is twice as big as in experiment 2. How about the resulting acceleration?

un Please type in a numeral.

un The doubled force was found to cause twice the acceleration. Please type 2.

Problem 5: This last question should be an easy one. The property of a body which makes it resist a change in its motion is __________.

(ca) inertia Glad you said that!

(wa) weight Wrong. Weight is the magnitude of the gravitational force pulling on the object. These experiments did not involve the force of gravity.

HINT: Think now; what is this film all about?

Film303

The next 2 questions will cover the concepts discussed in the PSSC film on inertial mass.

Problem 1: In the last film (inertia) it was demonstrated that if different forces are applied to the same object, the acceleration produced is proportional to the force. In this film, the force is kept constant and objects with different inertias are accelerated. If a = acceleration, I = inertia, the observations indicated that

a. does not depend on I

b. a is proportional to I

c. a is inversely proportional to I

(ca) c. Correct. Two disks fastened together has 1/2 the acceleration of one disk, for the same applied force. An idea learned in the previous film: for the same inertial mass, acceleration is proportional to force.

(wa) a. Wrong. Remember, two disks fastened together did not have the same acceleration as a single disk. Try again.

(wa) b. If this were so, two disks fastened together would have had twice the acceleration of a single disk, for the same applied force. The experiment showed the opposite. Now answer correctly.

Problem 2: The ratio of the inertia of a dictionary to the inertia of a disk was obtained by measuring the acceleration of the disk alone, and acceleration of the disk plus the dictionary, under the same force. (On page 19 of the booklet is a copy of the calculation done for this problem.) Going backwards through this calculation, can you figure the expected acceleration of a disk and two dictionaries, under this same force? Assume inertia of two dictionaries equals twice the inertia of one dictionary.

(ca) 3.2 cm/sec^2 Excellent! Too bad we can't test our prediction on Purcell's equipment. Remember, weight has played no part in these experiments. All the inertia experiments could have been performed in a space ship, far from earth, without gravity.

(wa) 3.2 Very good, you arrived at the right number. Type it in again with the correct units, please.

HINT: The ratio on the last line, 0.45, will now be twice as large, won't it? This makes the number on the next-to-last line (1.0 + 0.90) = 1.90 instead of 1.45. The acceleration of the disk alone will still be 6.1 cm/sec^2. See if you can finish up by working back to the second and then the first line.

Film 311

The following five questions cover the material presented in the PSSC film on energy and work.

Problem 1: In curve (C), if the spring is stretched to 0.5 meters, 25 joules of potential energy are stored in the spring. If this energy is released by letting the system do work to accelerate a 4.3 kilogram cart from rest, what will be the final kinetic energy of the cart? (discounting friction)

(ca) 25 joules Very good!

(wa) 25 25 fig newtons? 25 push-ups? 25 what?

un The spring when released, will give up all of its potential energy, which will be transferred to the kinetic energy of the cart.

un The final kinetic energy of the cart will equal the potential energy given up by the spring system, or 25 joules. Please type that in now.

Problem 2: Two forms of mechanical energy are ____________ energy and __________ energy.

(ca) kinetic and potential
Good. Let's continue.

HINT: One is energy of motion; the other is the energy stored in a system as a function of relative positions of bodies.

un Potential? Thermal? Kinetic? Nuclear? Which two are mechanical?

un Type kinetic potential.

Problem 3: Remember the ball that was lifted to a 3 meter height, then released? When the ball was halfway down in its fall, it had

a.. potential energy

b. kinetic energy.

c. potential and kinetic energy

Problem 4: If, at the end of its fall, the ball is allowed to fall on a spike in a piece of wood, driving the spike further in, some of the ball's kinetic energy is converted into ________ energy.

(ca) thermal
heat
Right.

(wa) internal Yes, but what kind of internal energy?

(wa) friction You're on the right track. We think of friction as a force, which would result in the conversion of kinetic energy into t________ energy. Try again.

HINT: The thermometer reading increased.

un Think of the names of some forms of energy--kinetic? potential? thermal? Name the correct one.

un The work is thermal--enter that now.

Problem 5: The work done by the net force acting on a system is a good measure of the energy gained (or given up) by the system. The work done by such a force F plotted against the distances through which it moves can be measured by the area under the curve. (See examples on page 19 in the booklet.) Let's do a calculation of curve type (B). How much work must be done to stretch this spring .10 meter? (Answer in joules or newton meters.)

(ca) .5 joules Excellent.

(wa) 1 joule You're close: but the work (the shaded area) is half the area of the rectangle. Try again.

HINT: Calculate the area of the shaded triangle.

un Please answer with a numeral followed by the word joules--spelled just like that. This machine is very choosy.

Film301

Problem 1: All of the many forces in nature can be understood in terms of the three basic types. See if you can name them. (One word each.)

(ca) gravitational, electrical, nuclear
Correct.

HINT: What type of force causes the fall of a body to earth? What type of force existed between the charged lucite rod and the ping pong ball in the film? What type of force is involved in an H-bomb explosion? Now enter all three types of forces.

(wa) Are you having trouble? If so, ask for a hint.

<u>Problem 2</u>: The force between two magnets, or forces of electromagnetic origin, would be classified under which of the three basic types? (One word answer.)

(ca) electrical Yes, forces of electric, magnetic, or electromagnetic origin are lumped together under the term "electrical".

(wa) gravitational No, gravitational is the force between two masses. Try again.

(wa) nuclear No. Remember, the two magnets cannot get close enough together for nuclear forces to operate, now try again.

HINT: The word "electromagnetic" is a clue.

<u>Problem 3</u>: In the film, the Cavendish experiment was performed to indicate the universality of gravitational attraction--in this case, between the box of sand and the bottle of water. The box containing the bottles had to be enclosed by screens for this demonstration because gravitational forces are relatively weak compared to __________ forces.

(ca) electrical Correct. Without the screening, stray electric fields would cause movement of the pendulum, obscuring the effect of the gravitational attraction.

(wa) nuclear Wrong. The screening would not have helped much if nuclear forces had been released. Try again.

(wa) gravitation You're putting me on. Come on now, answer correctly.

HINT: When Zacharias removed the screen and held a charged lucite rod near the bottle, the pendulum showed a large displacement. Try again.

un Answer gravitational, electrical, or nuclear.

Problem 4: In the Cavendish experiment, the sand box had to be quite close to the water bottle to cause a measurable force. The deflection of the electron beam in the cathode-ray tube increased as the magnet, or an atom's diameter. So these three types of forces have one thing in common: They all depend on ___________.

(ca) distance
length
separation
closeness
Correct.

un The pull between two magnets, for example, depends on the ______ between them. Type in the word.

Problem 5: At the end of the film, two small carts collide on a track. Then one cart is fastened down and covered with a black cloth, and the other cart is rolled to collide with it. How many bodies are involved in the force of this collision? (Answer with a numeral.)

(ca) 2 Correct, even when one body is so massive (such as the fixed cart) that it does not move, the force must involve at least two bodies.

(wa) 1 No. Even though one body is so massive (such as the cart fixed to the heavy desk) that it seems unaffected by the collision, a force always involves at least two bodies.

(wa) 3 This might be correct, if you are considering the fixed cart, and the desk to which it is clamped, as two separate bodies. The point to see here is that every force involves at least two bodies, never just one. The moving cart is one, the fixed cart the other. Please type in 2.

HINT: The fixed cart, and the heavy desk to which it is clamped, may be considered one body.

Force

The following section deals with the concept of force, covering the topic in four questions.

Problem 1: Four monkeys in a zoo all want to play with a chair at the same time. Monkey A pulls the chair north with a force of 15 newtons, monkey B pulls west with a force of 35 newtons, monkey C pulls south with a force of 25 newtons, and monkey D pulls east with a force of 25 newtons. In what directions will the chair be accelerated?

a. southwest

b. southeast

c. west

d. The chair will not be accelerated in any direction.

(ca) a. You're correct. You saw that the unbalanced forces were 10 newtons west and 10 newtons south. Therefore, the resultant will be in a southwest direction.

(wa) b. No. Notice that the force pulling west is greater than the force pulling east. Try again.

(wa) c. Wrong. It is true that monkey B is pulling harder than monkey D, but there is another unbalanced force. Look it over again and answer correctly.

(wa) d. No. How can you say that the chair won't move when there are unbalanced forces involved? Find the direction of the net force and answer the question correctly.

HINT: Let us find all of the unbalanced forces. In the north-south direction, there are 15 newtons north and 25 newtons outh, a new force of 10 newtons south. In the east-west direction there are 25 newtons east and 35 newtons west, a net force of 10 newtons pulling south. The resultant of these two equal forces will lie on the bisector of the angle they make with one another. Type in the correct response.

<u>Problem 2</u>: What would be the magnitude of the acceleration of a 3 kilogram mass which is acted upon by a force of 9 NEWTONS?

a. 27 m/sec^2

b. 3 m/sec^2

c. 1/3 m/sec^2

(ca) b. Correct.

(wa) a. No, force equals mass times acceleration. Try again.

(wa) c. No, force equals mass times acceleratinn, therefore acceleration equals force divided by mass <u>not</u> mass divided by force. Now try the problem again.

HINT: Remember, $F = ma$.

Problem 3: A body is moving in a circular path with constant speed. The acceleration of the body

a. points towards the center of the circle
b. points away from the center of the circle
c. is parallel to its velocity
d. is zero

(ca) a. Correct.

(wa) b. You're close; you realized that the acceleration must be at right angles to the motion, but is it towards or away from the center? Draw a rough picture and compare the circular path with an unaccelerated (tangential) path at one point on the circle.

(wa) c. Wrong. Remember that a moving object will move in a straight line unless acted upon by a force. Let's see what force is necessary to make an object move in a circle. To change the direction but not the speed of a moving object, the acceleration must be perpendicular to the direction of motion. Now you determine which way the acceleration acts and answer by typing the proper letter.

(wa) d. No, an object experiencing zero acceleration will move in a straight line, not a circle.

HINT: Acceleration perpendicular to the velocity changes the direction of motion but not the magnitude of the velocity.

Problem 4: An object whose mass is 50 kilograms is observed to be moving with an acceleration of 2 meters per second per second north. Four forces are acting on the body. Three of them are: 250 newtons north, 75 newtons east, and 150 newtons south. The fourth force must be

a. 100 newtons south
c. 150 newtons north
b. 75 newtons west

(ca) b. Good.

(wa) a,c. Wrong, if the object is being accelerated north, then the unbalanced force must be in a northerly direction. Draw a rough vector diagram and see which of the answers will produce the desired effect.

HINT: Draw a vector diagram and determine which of the answers will leave an unbalanced force acting in a northerly direction.

Energy

The following four questions review the concepts of kinetic and potential energy.

Problem 1: If kinetic energy is measured in joules, then potential energy is measured in __________?

(ca) joules Good, a joule is a kg X m^2/sec^2.

un Both kinetic energy and potential energy are energy. Therefore, they must have equivalent units. Now answer correctly by typing in the units in which potential energy is measured.

un Potential energy is measured in joules. Please type that in now.

Problem 2: Two balls, A and B, of equal mass collide elastically. Before collision A had a kinetic energy of 75 joules and B had a kinetic energy of 50 joules. After the collision,

a. The total kinetic energy of A and B is 125 joules.
b. The total kinetic energy of A and B is 25 joules.
c. Nothing can be aaid about the total kinetic energy.

(ca) a. Correct, total kinetic energy is conserved in elastic collisions.

(wa) b. No, the total kinetic energy is conserved in elastic collisions and would be the kinetic energy of A plus the kinetic energy of B. Now try again.

(wa) c. Wrong. Remember that total kinetic energy is conserved in elastic collisions. Now try again.

HINT: Kinetic energy is conserved in elastic collisions.

Problem 3: You are standing on a fire tower 50 meters above ground. What is your potential energy with regard to the ground if your mass is 80 kilograms?

a. 4×10^3 joules c. 9.8 m/sec^2

b. 3.92×10^4 joules d. I don't know.

(ca) b. Good.

(wa) a. No. I think you may have forgotten to convert mass to weight.

(wa) c. Wrong. 9.8 m/sec^2 is the acceleration due to gravity not energy. Answer by typing the proper letter.

(wa) d. Let's inspect the units to try to find a way to solve this problem. You know energy is measured in joules and a joule is a kilogram meter squared per second squared. The data we have is in meters and kilograms; therefore, we need meters per second squared. We know that the acceleration due to gravity is 9.8 meters per second squared. If we multiply that by your mass of 80 kilograms we get 80 k X 9.8 m/sec^2 = 7.84 X 10^2 kg m/sec^2, which is the same as 7.84 X 10^2 newtons (weight). If this were multiplied by 50 meters we would get 7.84 X 10^2 newtons X 50 meters = 3.92 X 10^4 joules. Now let's summarize how we found potential energy. Potential energy = weight X height where weight is in newtons, height is in meters and potential energy is in joules. To get weight from mass, we multiply mass by the acceleration due to gravity. Go through the problem for yourself.

<u>Problem 4</u>: An archer shoots an arrow with a mass of 100 grams straight up with a velocity of 40 meters per second. If the archer did not move, with what energy would t the arrow strike him on the head? (Ignore air resistance.)

a. 8 X 10^4 joules

b. 80 joules

c. 2 X 10^3 joules

(ca) b. Very good. You have applied the concept of conservation of energy to good effect in the solution of this problem.

(wa) a. No. You may have forgotten to put all of your units in the MKS system. Check for this error and figure your answer again.

(wa) c. Wrong. Remember the relationship for determining the kinetic energy of a moving object is: K. E. = 1/2 m v^2, use this to determine the kinetic energy of the arrow as it leaves the bow. Then determine the energy of the arrow when it strikes the archer on the head and answer the question.

HINT: OK. Let's follow the arrow through its flight. We know that as the arrow leaves the bow it has a kinetic energy of 1/2 m v^2 of 1/2 0.1 kg. (40 m/sec^2 which is equal to 80 joules.) As the arrow travels straight up, gravity accelerates the arrow down converting its kinetic energy to potential energy. At some point, all of its kinetic energy is converted to potential energy. Now the arrow begins to convert this potential energy to kinetic energy by falling under the influence of gravity. We know from the principle of conservation of energy that the arrow's energy remains constant regardless of the form that the energy is in. Therefore, at any instant the sum of the potential and kinetic energy is its original energy of 80 joules. Now what can you say about the energy of the arrow as it strikes the archer on the head? Look at the original choices and pick the correct one.

You have now completed the four examples dealing with energy. Consult page 17 of the supplementary booklet and select the next section you wish to review.

Mass

The following four questions explain the relationship between mass and weight.

Problem 1: In the MKS system of measurement, mass is measured in ________. (Type in your answer.)

(ca) kilogram Right. Let's continue.

un Mass is measured in kilograms. Please type that in now.

Problem 2: In this system of measurement, weight is found by multiplying mass by the acceleration due to gravity. The result of this multiplication is a force. The units involved are kg X m/sec^2. The correct name for this unit of measure is a ________.

(ca) newton Good. Let's use this information in some problems.

un kg m/sec^2 is a newton. Please type that in now.

Problem 3: A body has a mass of 100 kilograms on the earth. How much will the same body weigh on the moon? (The moon's gravitational acceleration is 1/6 that of the earth's.)

a. 16.6 kilograms
b. 163.3 kilograms
c. 163.3 newtons
d. 100 newtons
e. 100 kilograms

(ca) c. Very good. The body has a mass of 100 kilograms on the moon and its weight there would be:

$$1/6 \times 9.8 \text{ m/sec}^2 \times 100 \text{ k} = 163.3 \text{ newtons.}$$

(wa) a. Wrong. Its <u>mass</u> remains constant, but the <u>weight</u> changes with the gravitational field. Answer by typing the proper letter.

(wa) b. You are partly right, the numerical answer is correct but your units are wrong. We are looking for <u>weight</u> not mass.

(wa) e,d. No. Its mass on the moon (or anywhere, for that matter) is 100 kilograms, but we asked for the weight. Now answer by typing the correct letter.

HINT: The acceleration of gravity on the moon is $1/6 \times 9.8 \text{ m/sec}^2 = 1.63 \text{ m/sec}^2$.

<u>Problem 4</u>: A person whose mass is 75 kilograms is asleep on Miami Beach. What force does the sand of the beach exert on the person's body?

a. 75 newtons

b. 75 kilograms

c. 735 newtons

(ca) c. Excellent! You seem to understand that mass acted on by gravity exerts a force, and in this case, since the person is exerting a force down because of gravity acting on his mass and he is obviously at rest, there must be an equal but opposite force being exerted on the person to keep him at rest.

(wa) a. You're heading in the right direction. You realize that a newton is a unit of force, but you must remember that a kilogram of mass is not equivalent to a newton. Keeping that in mind, work the problem correctly.

(wa) b. No. Remember that a kilogram is a unit of <u>mass</u> not <u>weight</u>. Now answer the problem correctly.

HINT: Remember that a force is a product of mass and acceleration. In this case the acceleration is due to gravity. The person is exerting this force on the sand of the beach; however, he is at rest, so that there must be an equal but opposite force exerted by the sand of the beach on the person so that there is no net force to accelerate either the person or the sand. A kilogram is a unit of mass and a newton is a unit of force equal to a kilogram-meter per second squared.

Accel

The following four questions discuss the facts of acceleration.

Problem 1: An object is moving in a straight line with constant speed. Then its

a. acceleration must be constant but non-zero
b. acceleration must be changing at a constant rate

c. average velocity for any interval of the motion must be equal to its instantaneous velocity anywhere during the motion

(ca) c. Very good!

un If the speed is constant and the object is moving in a straight line then the velocity is a constant. Since the acceleration is the change in velocity per unit time, the acceleration would be zero.

un If velocity is constant, then the average velocity is the same for any time period. Now answer correctly.

un You know that an object moving in a straight line with a constant speed has no net force.

Problem 2: If an object is being accelerated such that only the direction of its velocity is changing, then the object is moving in a

a. straight line

b. circle

c. generally curving but non-circular path

(ca) b. Well done!

(wa) a. No, if the object is moving in a straight line then the direction of its velocity is constant. Now type in the correct letter.

(wa) c. No, if the object is moving in a generally curving but non-circular path then the magnitude of the velocity is also changing. Now answer correctly.

HINT: The moon is an example of a similar condition.

__Problem 3__: A body which weighs 2000 newtons is dropped from rest from a height of 1960 meters above the surface of the earth. When it strikes the ground, it is moving with a speed of 196 meters per second. If a body which weighs 200 newtons is dropped from rest from the same point, its speed upon striking the ground will be (neglect air resistance.)

a. 19.6 meters per second   c. 1960 meters per second

b. 196 meters per second

(ca) b. Good. You saw the same thing Galileo saw when he dropped a heavy ball and a light ball at the same time and height. They both hit the ground at the same time and with the same velocity.

(wa) a. Absolutely not. Remember that, in a vacuum, a feather will fall as fast as a lead shot. Answer by typing the correct letter.

(wa) c. Wrong. If you drop a paper clip and your shoe at the same time from the same height, they will both hit at the same time. Answer by typing the correct letter.

HINT: Drop a pencil and a shoe at the same time and height and observe which one, if any, hit the floor first.

__Problem 4__: Imagine for a moment that you are an electron traveling at high speed and just entering a magnetic field. If a moving electron is accelerated at right angles to its direction of motion in a magnetic field, in what kind of path will you be traveling while going through the magnetic field?

a. a straight line in your original direction of motion
b. a straight line at right angles to your original direction of motion
c. a curving path

(ca) c. Good. You seem to understand that acceleration at right angles to the direction of motion produces a circular path. This is the same principle that causes the moon to orbit the earth.

(wa) a. No. Remember that accelerating a moving object at right angles to the direction of motion causes a change of direction. Now answer correctly.

(wa) b. No, the electron cannot move in a straight line as long as it remains in the field becausr it continues to be accelerated at right angles to its instantaneous direction of motion. (Not at right angles to its original direction of motion.)

HINT: Let's leave off the fancy stuff about electrons and magnetic fields and speak of an object moving along at constant velocity. Someone turns on a fan which blows at right angles to the direction of the object's motion and the object is now being accelerated from the side. The resultant path will be a curve away from the fan. Now apply this to the problem and answer correctly.

Motion

The 3 problems which follow, cover the concept of force. They are similar to the problems you will see on the exam.

Problem 1: What would be the weight of a 4 kilogram mass at a point where g + 9.8 meters/second^2?

a. 4 kilogram

b. 39.1 kilogram

c. 39.2 newtons

d. 4 newtons

(ca) c. Correct.

(wa) a. No, remember weight is the force of gravity on a mass. Try again.

(wa) b. No, your multiplication is correct but remember that weight has the units of force not mass. Now type the correct answer.

(wa) d. Wrong, weight is equal to mass times the acceleration due to gravity. Now try again.

Problem 2: A block resting on the surface of the earth has a certain weight and mass. If the same block is placed on the moon where the acceleration due to gravity is about 1/6 that on the earth then

a. its weight and mass would be the same as on earth
b. the weight would be 1/6 and its mass would be the same as on earth
c. the mass would be 1/6 and its weight would be the same as on earth
d. the weight and mass would be 1/6 of that on earth.

(ca) b. Very good.

(wa) a. No, remember that weight is a force and depends both on mass and acceleration due to gravity. Try again.

(wa) c,d. No. Remember that mass is a universal property of a body and is the same anywhere in the universe, but that weight is used to describe the effect of gravity on the mass of a body.

Problem 3: Suppose we had the following forces acting on a 6 kilogram mass; 100 newtons north, 27 newtons east, 100 newtons south, and 33 newtons west. What would the acceleration be?

a. 1 m/sec^2 east

b. 36 m/sec^2

c. 1 m/sec^2 west

d. I do not understand.

(ca) c. Excellent, your understanding of forces appears to be quite satisfactory.

(wa) a. No, you have the right magnitude of the vector, but the wrong direction. Remember that in this type of problem the acceleration is in the same direction as the net force. Now type the correct answer.

(wa) b. Wrong, you seem to be having trouble with this concept. I suggest you reread pages 38 to 47 in your text, Elementary Physics, Van Name is the author. Then try again.

(wa) d. Remember $F = mA$ where F is the vector sum of all forces acting on the mass. Now try the problem.

Momentum

The four problems which follow are examples of the momentum problems you may see on the exam.

Problem 1: What is the magnitude of the momentum of a 35 kilogram mass with a speed of 7 m/sec?

a. 5 kg m/sec

b. 225 kg m/sec

c. 245 kg m/sec

(ca) c. Good.

(wa) a. No, remember momentum (P) equals mass (M) times velocity (V), P = mv.

(wa) b. Wrong, you seem to have an understanding of the concept of momentum, but you multiplied wrong (7 X 35 = 225).

HINT: Momentum equals mass times velocity.

Problem 2: Body A which has a mass of 7 kilograms and is traveling with a velocity of 9 m/sec north collides with Body B which has a velocity of 10 m/sec north and a mass of 15 kilogram. What is the total momentum?

a. 63 kilogram m/sec north

b. 213 kilogram m/sec north

c. 150 kilogram m/sec north

(ca) b. Very good.

(wa) a. Wrong. The momentum of Body A is 63 kilogram m/sec north, but the total momentum is the sum of the momenta of both bodies.

(wa) c. No, the momentum of Body B is 150 kilogram m/sec north, but the total momentum is the sum of the momenta of both bodies A and B.

HINT: Remember, the total momentum is the sum of the individual momenta. Now answer correctly.

Problem 3: Body A has a momentum of 60 kilogram meters/second east. It collides with Body B which has a momentum of 150 kilogram meters/second west. If the momentum of Body A is 70 kilogram meters/second west after the collision, what is the momentum of Body B after the collision?

a. 140 kg m/sec east

b. 20 kg m/sec west

c. 150 kg m/sec west

(ca) b. Excellent.

(wa) c. No. Remember that momentum is a vector and therefore its direction must also be considered when finding the total momentum. Try again.

(wa) a. No. Remember the total momentum before the collision must equal the total momentum after the collision. And, you must also remember that momentum is a vector quantity. That is, it has a direction. Now try the problem again.

HINT: Remember that momentum is a vector quantity, you must consider its direction.

Problem 4: Suppose Ball A has a mass of 5 kilograms and is moving with a velocity of 10 m/sec; it collides with Ball B which has a mass of 10 kilogram and is standing still. If the balls collide head-on, what could be said for velocities of A and B after the collision?

a. the velocities of A and B remain the same
b. A and B each have a velocity of 5 m/sec
c. if the collision is elastic, conservation of kinetic energy and momentum allow us to solve for the velocities.

(ca) c. Correct.

(wa) a. No, remember Ball B is free to move and it would start to move after the collision.

(wa) b. No, the conservation of momentum principle states that the total momentum of a system remains constant.

HINT: Momentum and energy are conserved. Now answer correctly.

You have now finished the review section covering the concept of momentum.

Work

The following four questions discuss the concept of work.

Problem 1: Neglecting friction and air resistance, which of the following is not an example of work?

a. pushing a box up an inclined plane
b. carrying a box across a tennis court
c. carrying a box up a flight of stairs

(ca) b. Correct, no work is done because there is no component of force in the horizontal direction of motion.

(wa) a. No, there is a force acting along the plane and thus work would be done.

(wa) c. No, there is a component of the force in the direction of motion (vertical).

HINT: Which answer choice has no component of force in the direction of motion?

Problem 2: How much work is done on a 1000 kg satellite to keep it in an orbit 400 km from the surface of the moon?

a. pi X 8.4 X 10^5 joules

b. pi X 4 X 10^5 joules

c. zero

(ca) c. Good.

(wa) a,b. No, remember that work equals the component of force in the direction of motion times the distance moved. Now answer correctly.

HINT: How far does the satellite move in the direction of the force? Now answer correctly.

Problem 3: How much work must be done to accelerate a 10 kilogram mass from rest to a speed of 3 m/sec?

a. 13 joules

b. 30 joules

c. 45 joules

(ca) c. Very good.

un Remember that the work done must equal the kinetic energy gained. Now try again.

un Remember that work done must be equal to kinetic energy gained. ($W = 1/2\ mv^2$).

Problem 4: An elevator lifts a person with a mass of 50 kilograms to a height of 150 meters. How much work has the elevator done on the person?

a. 7.5 X 10^3 kilogram meters

b. 7.35 X 10^4 joules

c. 7.5 X 10^3 joules

d. 490 newtons

(ca) b. That's right.

(wa) a,c. No, remember work is the component of force in the direction of motion times the distance moved. Answer by typing the correct letter.

(wa) d. That's part of it, 490 newtons is the person's weight, now you have to do something to the weight to get work. Try again.

HINT: The elevator lifted a weight of 50 kg X 9.8 m/sec^2 to a height of 150 m. How much work did it do?

You have now completed the four questions dealing with work. Consult page 17 of the supplementary booklet to select the next area you would like to review.

Current

The following four questions review the concepts of electrical currents.

Problem 1: A battery whose EMF is 120 volts is connected to a circuit whose total resistance (including the battery) is 40 ohms. The current will be:

a. 3 amperes

b. 1/3 ampere

c. 4800 amperes

(ca) a. That's right.

(wa) b. Wrong. EMF equals current times resistance. Therefore current equals EMF divided by resistance.

(wa) c. No, Ohm's law tells you that the current is equal to the EMF divided by the total resistance. Now try again.

HINT: Remember that V = RI.

Problem 2: A small charged sphere is in a constant electric field between two large parallel plates. If the sphere carries a charge of 6 coulombs and the potential difference between the plates is 30 volts. How much work is done in moving the sphere from one plate to the other?

a. 5 joules

b. 180 joules

c. 1080 joules

(ca) b. Right.

(wa) a. No. The work done is equal to the potential energy gained, which is proportional to the amount of charge moved. Try again.

(wa) c. Wrong. Remember the work done on the charge is proportional to the amount of the charge times the potential energy difference. Try again.

HINT: Remember that a volt is defined as a joule per coulomb.

Problem 3: How much power is used by an electric motor that has a potential difference across its terminals of 34 joules/coulomb and a current through it of 100 amps? (Type in your answer--be sure to include the proper units.)

(ca) 340 watts That's right.

HINT: Remember P = IV.

un No, power is measured in watts and is the product of the current and potential difference.

un No, follow this: P = IV = 10 amps X 34 volts = 340 watts. Now type in the correct answer.

Problem 4: How much energy would be made available by allowing 300 coulombs to fall through a potential difference of 1,200 volts? (Please type in your answer.)

(ca) 360,000 joules
Good.

HINT: Remember that a volt is defined as a joule per coulomb.

un Sorry. Simplify and inspect the units for a possible solution to the problem.

Film421

The next three questions cover the points presented in the PSSC film on the Franck-Hertz Experiment.

Problem 1: Although Franck and Hertz, at the time, were unaware of Bohr's atom model, their experiment later proved to be valuable verification for Bohr's model because

a. atoms can absorb energy in inelastic collisions with electrons
b. electrons could be accelerated through mercury vapor
c. the smallest energy that an electron can impart to a mercury atom is 4.9 electron-volts.

(ca) c. Right. And since the atom can accept energy only in certain amounts, we conclude that atoms can exist only in certain discrete energy states.

(wa) a. Although this is true, there is a further observation which is particularly important to the Bohr theory. Try again.

(wa) b. No, this was already known. Try again.

HINT: Remember the regularity of the peaks and valleys in anode current as the accelerating voltage was increased?

Problem 2: The whole tube was placed in a heating jacket for this experiment, in order to

a. boil electrons off the cathode
b. vaporize the mercury
c. accelerate the electrons

(ca) b. Correct, mercury vapor throughout the tube was necessary for the experiment.

(wa) a. No, there is a special heater inside the cathode to do this. Try again.

(wa) c. No. This is done by the voltage difference between accelerating grid and cathode. Try again.

HINT: At room temperature, almost all the mercury was in a "blob" in the tube.

Problem 3: Five-volt electrons pass through an unknown gas in a similar tube, and are found to retain one electron-volt of energy. From the relationship E (electron-volts) = 12400/wavelength (angstroms), calculate the wavelength of light that may be emitted by the excited gas.

a. 3100 angstroms

b. 12400 angstroms

c. 2480 angstroms

(ca) a. Very good.

(wa) b. Wrong. If the electrons retain 1 ev of energy, the atoms absorb 4 electron volts. Try again.

(wa) c. Wrong. The electrons retain 1 ev of energy, so the atoms absorb only 4 electron volts. Try again.

HINT: The wavelength (in angstroms) = 12400/energy (in electron volts) which the atom absorbs from the electron. Remember the electron after collision keeps only 1 ev of its original 5 electron volts.

Mag

The following four questions discuss the properties of magnetism.

Problem 1: Do the lines of force in a magnetic field form closed loops?

(ca) yes Correct.

(wa) no. Wrong, unlike the lines of force in an electric field, magnetic field force lines do form closed loops. Now answer correctly.

Problem 2: How does the magnetic field strength produced by a current-carrying wire depend on the magnitude of the current? It is

a. directly proportional to the magnitude of the current
b. directly proportional to the square of the magnitude of the current
c. inversely proportional to the magnitude of the current

(ca) a. Correct.

(wa) b. No, but it is true that magnetic field strength B is larger for larger currents. Try again.

(wa) c. Wrong. This would mean that extremely high fields would be experienced as the current in the wire is reduced toward zero. Try again.

HINT: The magnetic field produced by an electric current increases in flux density linearly as the magnitude of the current.

Problem 3: A proton is a charged particle with a + elementary charge. A proton initially moving with constant velocity enters a magnetic field which points at right angles to its direction of motion. The path followed by the proton in the field will be:

a. a straight line in the direction of the field
b. undeviated by the field
c. circular

(ca) c. Very good.

(wa) a. No, the right hand rule for the force on a charged particle moving at right angles to a magnetic field tells you that the resulting force is always at right angles to the velocity and to the magnetic field. Now try again.

(wa) b. Wrong. Any charged particle moving at right angles to a magnetic field experiences a force which is not in the direction of motion. This force is proportional to the charge on the particle, its velocity, and the size of the magnetic field component perpendicular to the velocity. Remember the right hand rule and try again.

HINT: Remember any moving charge whose velocity is perpendicular to any component of a magnetic field experiences a deflecting force.

Problem 4: A conductor carrying 3×10^4 amps extends 50 cm through a magnetic field of average strength 3×10^{-1} webers/m^2. What force is acting on the wire due to the magnetic field?

a. 4.5×10^3 newtons

b. 100 newtons

c. 9×10^3 newtons

(ca) a. Your calculations are correct.

(wa) b,c. No, the force on a conductor is given by the following relationship: F = BIL.

HINT: The force on a current carrying conductor in a magnetic field is proportional to the strength of the field, the magnitude of the current, and the length of the conductor in the field.

Modps

The next seven questions will help you to understand the concepts of quantum mechanics and particle waves.

Problem 1: A single bundle or quantum of radiation is called

a. proton

b. photon

c. photoelectron

(ca) b. Very good.

(wa) a. No, a proton is a positively charged particle. Try again.

(wa) c. No, photoelectrons are the electrons which comprise the current in the photoelectric effect. Try again.

HINT: If you really don't know, call the proctor for help.

Problem 2: In the experiment on the photoelectric effect, it is found that the maximum energy of a photoelectron produced from a given surface by a light source is independent of the

a. wavelength of the incident light
b. intensity of the incident light
c. neither of these

(ca) b. Well done.

(wa) a. No, the maximum energy varies linearly with the frequency and therefore, wavelength of the incident light. Try again.

(wa) c. No, it is independent of one of these. Which one?

HINT: The intensity of the incident light determines the number of photoelectrons produced.

Problem 3: Some photographic materials can be handled safely in red light but are spoiled instantly when a yellow light is turned on. How do you account for this?

a. the frequency of yellow light is sufficiently high so that the photons have enough energy to interact with the material
b. the yellow light is brighter
c. the wavelength of the red light is too small to affect the material

(ca) a. Very good.

(wa) b. No, the brightness of the two lights could be the same. What is the physical difference between red light and yellow light? Try again.

(wa) c. On the contrary, red light is on the longer wavelength end of the visible spectrum.

HINT: Reflect for a moment on the wavelengths involved and the relationship between energy and wavelength.

Problem 4: Diffraction effects cannot be observed with baseballs because

a. only photons of light have the wave-particle dual nature
b. their wavelengths are too small
c. the quanta of energy bundles of baseballs are so large they do not move along continuous paths.

(ca) b. True, at any practical speed.

(wa) a. Wrong. The wave-particle duality is true for <u>all</u> matter, including light.

(wa) c. No, for microscopic objects the energy bundles are very small.

HINT: At any practical speed, what wavelength would a baseball have?

Problem 5: If an electron has momentum 1000 kilogram-meters per second, and a proton has momentum 2000 kilogram-meters per second, then according to de Broglie's postulate,

a. the wavelength of the electron is larger than that of the proton
b. the wavelength of the electron is smaller than that of the proton
c. they have the same wavelength.

(ca) a. Right.

(wa) b. No. Remember, de Broglie postulated that the wavelength is <u>inversely</u> proportional to the momentum. Now answer correctly.

(wa) c. Wrong. De Broglie postulated that the wavelength is inversely proportional to the momentum. Since the two particles do not have the same momentum, they cannot have the same wavelength. Try again.

HINT: Wavelength is inversely proportional to momentum.

Problem 6: The first energy level above ground state for the mercury atom is 4.9 electron-volts. An electron whose kinetic energy is 4.2 electron-volts collides with a mercury atom. What will be the kinetic energy of the electron after the collision?

a. zero
c. 4.9 electron-volts
b. 4.2 electron-volts

(ca) b. Excellent.

(wa) a. No, the electron's kinetic energy is not sufficient to raise a mercury atom to its first excitation state therefore, <u>no</u> energy is transferred to the atom. Try again.

(wa) c. Wrong. The electron does not absorb energy from the atom. Try again.

HINT: Nothing happens when supplied energy is not sufficient to raise an electron in the atom to a higher energy level.

Problem 7: Atom A emits a photon with a wavelength of 6800 Angstroms. Atom B enits a photon with a wavelength of 3400 Angstroms.

a. atom A loses twice as much energy as atom B
b. atom B loses twice as much energy as atom A
c. the atoms lose equal amounts of energy

(ca) b. Right you are.

(wa) a. No, for a photon, the frequency equals the speed of light divided by wavelength. How does energy depend upon the frequency? Try again.

(wa) c. Wrong. If the photons had the same energy, they would have the same frequency and therefore the same wavelength. Try again.

HINT: Energy equals Planck's constant times frequency.

Atmod

The following five questions cover the characteristics of the Thomson, Rutherford, and Bohr atom.

Problem 1: Before the Rutherford experiment was performed, Sir. J. J. Thomson's "Plum pudding model" of the atom was generally accepted. This model described the atom as

a. a sphere of negative electricity in which are embedded positive particles
b. a sphere of positive electricity in which are embedded negative electrons
c. a small "solar system" arrangement of protons and electrons.

(ca) b. Right.

(wa) a. Not quite. This is a pudding but which are the plums? Try again.

(wa) c. Wrong. This model came after Rutherford found evidence that most of the volume of the atom is empty space. Try again.

HINT: This is a memory question, try all of the answers.

Problem 2: In his scattering experiment, Lord Rutherford observed that:

a. all of the alpha particles were scattered within a few degrees from the center of the atom
b. a few alpha particles were deflected well away from the center of the atom
c. no alpha particles were deflected.

(ca) b. Very good.

(wa) a. No, this is what Thomson predicted with his model but Rutherford's experiment showed that this was not true.

(wa) c. No, this was only true when there was no metal foil in the path of the beam.

HINT: Try and remember what happened when the alpha particles hit the thin gold foil.

Problem 3: Which of the following is not a property of the Rutherford model of the atom?

a. most of the mass of the atom would be concentrated at the nucleus (which would be positively charged)
b. the negative electrons could only have certain energies
c. the light electrons traveled about the nucleus in various orbits.

(ca) b. Right, this is not a property of the Rutherford model. It is a property of Bohr's model of the atom.

(wa) a. No, this is the property of Lord Rutherford's model which explains deflection through large angles.

(wa) c. No, this is a property of Lord Rutherford's model.

HINT: What was Bohr's model like?

Problem 4: In his model of the atom Neils Bohr postulated that the electrons exist as standing waves in their orbits around the nucleus. This explained why only certain orbits are allowed because

a. the standing waves will only fit into orbits with a circumference which is a whole number of times as long as the wavelength of the electron waves
b. protons cannot exist as waves
c. only certain electrons are light enough to have standing waves.

(ca) a. Very good, indeed!

(wa) b. No, the protons are considered to be concentrated at the nucleus, therefore, their wave properties, which do exist, do not affect the orbits of the electrons.

(wa) c. No, all electrons do have the same mass.

HINT: Standing waves require certain things, one of them is a set distance.

Problem 5: On the basis of Bohr's model of the atom, relationships can be derived which make possible the calculation of the line spectrum of the hydrogen atom. This model makes use of the following concepts:

a. Coulomb's law, and radiation from accelerating charges
b. Coulomb's law, and the quantization of absorption and emission of energy
c. gravitational attraction, and the quantization of energy.

(ca) b. That's right.

(wa) a. You're half right: Coulomb's law is used. Remember, radiation from accelerating charges was one of the troubles with the Rutherford model. Try once more.

(wa) c. You're half right, the quantization of energy emission and absorption is an important part. But the centripetal force in the atom is not that of gravitational attraction. Now answer correctly.

HINT: This is a memory question, try all of the answers.

Induct

The next three questions cover the concept of induction.

Problem 1: A 0.3 meter coil of wire is concentric to a 0.5 meter coil of wire. If a current of 3 amps at 6 volts is started in a clockwise direction in the 0.3 m coil, in what direction will the induced current in the 0.5 meter coil flow?

a. clockwise
b. counter clockwise
c. no current will flow because the 0.3 meter coil is inside of the 0.5 meter coil.

(ca) b. That's right. You applied Lenz's law to the solution of this problem.

(wa) a. I'm sorry but that's not right. Remember Lenz's law tends to retain the status quo. Please try again.

(wa) c. No, the fact that the primary coil is inside of the secondary coil does not mean that the nagnetic flux change produced will not affect the secondary. Remember Lenz's law and try again.

HINT: Remember that Lenz's law means that the status quo tends to prevail.

Problem 2: A small loop, area A, is in a constant magnetic field of magnitude B produced between two pole pieces whose area is much larger than A. If the loop is perpendicular to B, and maintains this orientation as it moves sideways to a new position still within the constant field, the EMF induced in the loop by the motion

a. depends on how fast the loop is moved
b. is zero
c. is a function of the constant magnitude of the field.

(ca) b. Very good.

(wa) a. Wrong. Since the loop stays in a constant magnetic field, perpendicular to the loop, the amount of flux through the loop does not change. Try again.

(wa) c. Wrong. Remember, the EMF induced is proportional to the rate of change of flux through the loop. If B and A are not changing, the flux is not changing. Try again.

HINT: How much does the flux through the loop change? Now apply this to the problem.

Problem 3: A magnetic field passes through a closed loop of conducting wire. If the magnetic field suddenly begins to decrease, a current will be induced in the wire. According to Lenz's law, the magnetic field set up by this induced current will have the direction and magnitude necessary to

a. cause the net field through the loop to decrease twice as rapidly
b. keep the net field through the loop the same as it was before the decrease started
c. reverse the direction of the field through the loop

(ca) b. Very good.

(wa) a. Wrong. Lenz discovered that the flux due to the induced current opposes the flux change that induced the EMF in the first place. In other words, the laws of energy conservation tend to limit the induced current.

Film419

The following four questions discuss the material covered in the PSSC film "Interference of Photons".

Problem 1: A very small amount of light is allowed to pass through a double slit and fall on a photomultiplier. As the double slit is moved transversely to the light beam, an interference pattern is measured by the photomultiplier. The maxima and minima observed by the photomultiplier constitute an interference pattern. Assuming that the light is monochromatic, the photons arriving at the maxima ________ than those arriving at the minima.

a. have more kinetic energy

b. are of smaller wavelength

c. are more numerous.

(ca) c. Correct.

(wa) a,b. No. The photons all have the same energy and wavelength, for monochromatic light. Now answer correctly.

HINT: Monochromatic light has only one wavelength, one frequency.

Problem 2: From the ammeter current, Dr. King estimates about 10^7 photons/sec arrive at the central maximum in the interference pattern. The speed of light is 3.0×10^8 m/sec, so the average distance between photons is

a. 30 meters

b. 3×10^{15} meters

c. .033 meters

(ca) a. Very good. Since the box containing the apparatus is only 2 meters long, we conclude there is rarely more than one photon in the box at a time. Keep this in mind for the next question.

(wa) b. Wrong. You seem to have multiplied where you should have divided. Try again.

(wa) c. Wrong. If you divided 10^7 by 3×10^8, this is the number of photons/meter. You want meters per photon. Now answer correctly.

HINT: Meters/sec divided by photons/sec equals meters/photon.

Problem 3: The interference pattern examined with the photomultiplier is

a. due to photons interfering with other photons
b. characteristic of one photon itself
c. observable only with weak light input.

(ca) b. Right! The interference pattern (a wave concept) predicts where the photon (particle) is most likely to be found.

(wa) a. No. If there is rarely more than one photon in the box at a time, how can they interfere with each other? Try again.

(wa) c. Wrong. You'd still get the pattern with stronger light. But then you'd have many photons in the box at the same time. Try again.

HINT: Remember, from the previous question, that there is rarely more than one photon in the box at a time.

Problem 4: The purpose of the experiment was to demonstrate the

a. wave nature of light
b. particle nature of light
c. dual (wave-particle) nature of light

(ca) c. Yes, we see that both concepts are needed to describe the behavior of light.

(wa) a,b. No, the interference pattern (waves) predicts where the photon (particle) is most likely to be found.

HINT: The interference pattern (waves) predicts where the photon (particle) is most likely to be found.

Film418

The following three questions cover the PSSC film "photons". See page 28 of the booklet for a diagram of the equipment used in this film.

Problem 1: The purpose of the experiment in the film was to demonstrate the

a. wave nature of light
b. particle nature of light
c. dual (wave particle) nature of light.

(ca) b. Correct.

(wa) a,c. No. The wave properties of light were not evident in this experiment. Try again.

HINT: Did you see anything in the experiment that could not be explained by the particle theory of light?

Problem 2: The intensity of light input to the photomultiplier is cut way down by filters

a. so individual photoelectrons may be detected on the oscilloscope
b. to avoid saturating the photomultiplier
c. so the room temperature will remain constant.

(ca) a. Exactly! This was essential in order to see if any individual photoelectrons were released in less than the 1/2000 sec predicted by a "continuous flow" model of light energy transport.

(wa) b. No, other requirements necessitated working well below this saturation level. Try again.

(wa) c. Wrong. There was a much more restrictive requirement. Besides, the filters didn't keep the heat from ra the room's temperature. Try again.

HINT: With no filters, the effect of the large number of photoelectrons is to form a smooth, steady pulse shape.

Problem 3: If light energy comes in "package's" instead of continuous flow, you'd expect to

a. have to leave the shutter open a full 1/2000 sec before a pulse is seen on the oscilloscope
b. find some pulses occur before the full 1/2000 second
c. find exactly one pulse every 1/2000 second.

(ca) b. Right. As shown in the film, some light "packages" get through the shutter during the 1/5000 sec. it is open on each rotation, and cause photoelectrons to be ejected. These are evidenced by the pulses on the oscilloscope.

(wa) a,c. No. A "package" of light (or even two or three) may get through the shutter during the 1/5000 sec. it is open on each rotation. Try again.

HINT: Remember the milk cartons getting through the gate during a short open period.

Exam4A

Problem 1: Two charged bodies are 15 cm apart. Body A is immobilized and carries a +6 charge. Body B is free to move and carries a -2 charge. Therefore, the 1.84×10^{-26} newton force between A and B will do work on B to ________ the distance between them.

(ca) shorten
decrease
Correct.

un Wrong.

Problem 2: If the charge on Body B in question 1 were increased to -6, what would the force between A and B become when they were 15 cm apart?

(ca) 5.52×10^{-26} n Correct.

un Wrong.

Problem 3: If the charge on Body B in question 1 were reduced to zero, what would the force between A and B become?

(ca) zero Correct.

un Wrong.

Problem 4: A metal ball is charged by being touched by an identical ball carrying a charge of -400. The ball is then touched by another identical ball carrying a charge of +360. The sign and magnitude of the charge on the first ball is then __________.

(ca) -20 Correct.

un Wrong.

Problem 5: Coulomb's law predicts that the electric field strength inside of a charged, hollow, conducting sphere is ______.

(ca) zero Correct.

un Wrong.

Problem 6: The medium which carries light waves is the _____ _____.

(ca) electromagnetic Correct.

un Wrong.

Problem 7: The lines of force in a _____ field do not form closed loops and give the direction of the field at any point in the field.

(ca) electric Correct.

un Wrong.

Problem 8: The lines of force in a ______ field form closed loops and give the direction of the field at any point in the field.

(ca) magnetic Correct.

un Wrong.

Problem 9: There is a potential drop between two points in a direct current circuit of 12 volts. If there is a resistance between the two points of 2 ohms, then the current flowing between the two points is ________.

(ca) 6 amp Correct.

un Wrong.

Problem 10: A closed loop of wire is held in a decreasing magnetic field. If the direction of the magnetic field is through the loop from right to left, then the induced current in the loop will form a magnetic field which goes through the loop from ______ to ________.

(ca) right left Correct.

un Wrong.

Problem 11: Magnetic fields exert forces on _____ charges only.

(ca) moving
traveling
Correct.

un Wrong.

Problem 12: That electrical charge comes in multiples of a basic, natural unit of charge was shown in the _____ experiment.

(ca) Millikan Correct.

un Wrong.

Problem 13: According to de Broglie's postulate, if an electron and a steamship both have the same momentum, then the wavelength of the steamship compared to the wavelength of the electron is ________.

(ca) same Correct.

un Wrong.

Problem 14: An experiment in which an alpha particle beam was directed at gold foil caused ________ to formulate a new atom model. (Last name only, please).

(ca) Rutherford Correct.

un Wrong.

Problem 15: Classical physics has trouble explaining why the _____ atom model doesn't radiate all of its energy and collapse. (Last name only, please.)

(ca) Rutherford Correct.

un Wrong.

Problem 16: That only certain orbits, or energy levels are allowed for electrons, and that electrons give up set quantities of energy when moving between orbits are properties of the ________ atom model. (Last name only, please.)

(ca) Bohr Correct.

un Wrong.

Problem 17: A certain electromagnetic wave has a frequency of 10^7 cycles per second. Another wave has a frequency of 10^{11} cycles per second. When the energy of the 10^7 frequency wave is compa ed to the 10^{11} frequency wave it is found to be _______.

(ca) smaller   Correct.

un   Wrong.

Problem 18: In Sir J. J. Thompson's model of the atom, the "pudding" was composed of __________ charge.

(ca) positive   Correct.

un   Wrong.

Problem 19: Can the interaction of light and atomic electrons be explained in terms of quantum mechanics?

(ca) yes   Correct.

un   Wrong.

Problem 20: What is the maximum change of magnetic flux through a coil with an enclosed area of .01 m^2 which rotates in a magnetic field of strength 10 webers/m^2.

(ca) 1 weber   Correct.

un   Wrong.

You have now completed the constructed response sample exam. Turn to page 24 of the booklet and select the area you would like to review or type sign off if you have completed this review.